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BULLETINS

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July, 1926 to December, 1927

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Ontario Department of Agriculture

HORTICULTURAL EXPERIMENTAL STATION
VINELAND STA., ONT.

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BULLETIN 319

NURSERY STOCK IDENTIFICATION

PLUMS, PEARS, PEACHES, CHERRIES.

By

W. H. UPSHALL, B.S.A.
Special Investigations.

ONTARIO

TORONTO, ONTARIO, JULY, 1926

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NURSERY STOCK IDENTIFICATION

PLUMS, PEARS, PEACHES, CHERRIES

W. H. Upshall.

Fruit growers and nurserymen alike have annually suffered financial loss from the planting of fruit trees subsequently found to be untrue to name. The years of waiting for these trees to come into bearing are a loss to the grower, and the replacement of such trees constitutes a distinct loss to the nurseryman. A method of avoiding this dual loss should therefore be doubly welcome.

Shaw (1) of Massachusetts, working with apples, has definitely demonstrated that apple varieties can be identified in the nursery row by the trained observer, from leaf and other growth characters. In this way mixtures can be eliminated. Commercial application of Shaw's investigations is now being made, certified nursery stock of certain apple varieties being listed by several nurserymen in the United States.

The work with apples indicated the possibility of similar methods of identification for other fruits. With this in mind, the writer has been engaged for three years in a study of the tree growth characters of varieties of plums, pears, peaches and cherries, commercially grown in the Province of Ontario. Practical application of the results of these investigations was made in 1924 and 1925, as will be noted later in more detail.

It is reasonable to expect that varietal differences are not confined to the fruits alone, but that there may be points of distinction just as well marked in tree characters. The truth is that leaf and other growth characters often prove to be useful in the final identification of varieties, the fruits of which may be very similar. The investigations of Shaw, already referred to, on apple varieties and the way he has made use of the information gained, has resulted in an increased interest in the various tree characters. Alderman and Shoemaker (2) have studied the plum varieties commonly grown in Minnesota and have drawn up a classification based on growth characters. Nor has identification of varieties by this method been confined to the tree fruits only for Grubb (3) in England and Winter (4) in Minnesota have outlined systems of identification of red raspberries applicable to varieties grown in their respective countries. It is quite possible that in the course of time all common varieties of fruit plants may be identified by this method.

In this publication the more important varieties of pears, plums, peaches and cherries grown in Ontario nurseries are considered, and, as a result of three years' study, a system of classification based on the characters exhibited by nursery trees is offered. In the descriptions of varieties only the more important characters useful in identification are given and there has been no attempt to present complete descriptions. Furthermore, it is quite possible that the writer has failed to observe characters which are just as useful in identification as the characters which have been noted.

Commercial varieties only have been studied in detail. In the case of peaches, other varieties have been included in the key to the identification of varieties in order to make a more complete classification. With all fruits only the more important commercial varieties were certified to be true to name in the nursery row. In the first place, it is impossible to become sufficiently familiar with the numerous minor varieties which are being grown in the nurseries; secondly, nurserymen as well as fruit growers realize that fewer varieties should be grown. By certifying only recommended varieties it is hoped to encourage fruit growers to select from this list and in that way urge the nurserymen to reduce the number of varieties being grown for sale.

NURSERY INSPECTION RESULTS

A short summary of the nursery inspection results of 1924 and 1925 may further serve to indicate the benefits to be derived from a system of identification of stock in the nursery row. In 1924 only a small portion of the salable stock of fruit trees in Ontario was examined. A total of 3,850 trees were found to be untrue to name. Of these, 2,100 were peaches, 1,050 plums and 700 apples. It is interesting to note that over half the mixtures in peach stock were Triumph mixed in Yellow Swan. This mixture occurred in three nurseries and was the result of an interchange of bud sticks. Although this mixture had been present for a number of years none of the nurserymen were aware of it.

In the summer of 1925 practically all the salable stock of fruit trees grown in Ontario, totalling 856,100, was inspected by the writer. The mixtures amounted to about 13,000 trees or one and one-half per cent. of the total. Considering the opportunities for error in the various nursery operations, this is a remarkably good record. Based on total salable stock the lowest percentage of mixtures in any nursery was three-tenths of one per cent. and the highest, thirteen per cent. All trees untrue to name were eliminated in the nursery either by breaking down, or, where possible, labelling with the correct name. In 1925 nursery firms were issued certificates stating that certain kinds and varieties of fruits were true to name as they stood in the nursery rows. Further mixture, through carelessness, may occur during and after digging operations. Experience indicates, however, that most mixtures occur previous to digging time, mainly as a result of the use of incorrectly named budwood, etc. A mixture, once established, is likely to be perpetuated by the taking of bud wood, year after year, from the nursery stock itself. It may be mentioned, also, that some of the worst mixtures resulted from securing bud wood from trees in growers' orchards thought to be true to name, but which subsequently were shown to be incorrectly named.

VARIETY DESCRIPTIVE NOTES

Owing to variations in characters resulting from different growth conditions, it is difficult to make any hard and fast descriptions. Although certain characters are not altered by conditions others are extremely variable; therefore, of necessity, the classification and descriptions as given in this publication should be used only to simplify the study of varieties. Familiarity with the appearance of varieties in the nursery row comes only from a constant association with the young trees and not from a study of written descriptions and classifications.

*Actual size photographs of typical leaves of pear and plum varieties appear herewith. Because of the extreme variation in the leaf characters of cherries and peaches, photographs of these have been purposely omitted. Moreover, most of the characters useful in the identification of cherry and peach varieties cannot be seen in leaf photographs.

PLUMS

I—Shoots smooth (glabrous).

(A) Tip leaves pink or light green.

(*a*) Glands usually on petiole.

1. *Abundance*—upright habit of growth; shoots, reddish; leaves flat or slightly folded back, tip abrupt; glands, several, small; serrations, fine, irregular.
2. *Burbank*—vigorous, spreading grower; serrations, fine, irregular; glands, several, small; leaves often evenly folded back.
3. *Red June*—fairly upright grower; shoots, dark red; leaves, glossy; tip leaves pink; lenticels more numerous and more prominent than on Abundance.
4. *Shiro*—vigorous, upright spreading grower; shoots, many, fine and dark red; leaves small, dull colour, nearly flat, tip abrupt.
5. *Bradshaw*—shoots, few, pink and upright; light green foliage; leaves rigid, folded back, waved and twisted; glands usually stalked.
6. *Lombard*—shoots, stouter than Bradshaw and purplish in colour; leaves folded back and waved; glands often stalked.
7. *Pond*—shoots, purple; foliage, fairly dark green; leaves rolled back from margins; upper surface of older leaves pubescent.

(*b*) Glands usually on blade.

1. *Grand Duke*—shoots, purplish; tip leaves, dark pink; leaves, thick, glossy dark green, mid-rib reflexed; serrations, shallow and fairly sharp.
2. *Yellow Egg*—shoots, few, pink; foliage, light green; serrations, fairly blunt; fine pubescence on upper surface of older leaves.

(B) Tip leaves, dark red

(*a*) Glands usually on petiole.

1. *Fellenburg*—habit, upright spreading; shoots, slender, with marbling colour effect; leaves, much longer than broad; serrations, comparatively deep and serrate in nature at the tip of the leaf.

(*b*) Glands usually on blade.

1. *Coe's Golden Drop*—shoots, purple; tip leaves just slightly red; foliage, dark green; leaves folded upwards and mid-rib reflexed, broadly waved with tip often twisted.
2. *German Prune*—branches fine, lower ones at right angles to the trunk or drooping; leaves, narrow oval in shape; serrations, fairly sharp and deep.
3. *Reine Claude*—shoots, purplish; foliage, very light green; leaves, rolled from tip; glands, large; serrations, blunt and shallow.

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*Thanks are due Mr. J. R. van Haarlem of the Station Staff for the photographic work necessary for this bulletin.

II—Shoots pubescent.

(A) Tip leaves pink or light green.

(*a*) Glands usually on petiole.

1. *Imperial Gage*—habit, upright; shoots, purple; leaves, rigid, folded upwards, with reflexed mid-rib; glands, round with depressed centre; pubescence, very light.

(*b*) Glands usually on blade.

1. *Shropshire Damson*—numerous thorny spurs; leaves, small; pubescence, light.
2. *Washington*—shoots, pink; leaves, large, light in colour and slightly rolled back; glands widely spread apart; pubescence, very light.

(B) Tip leaves dark red.

(*a*) Glands usually on petiole.

1. *Glass*—shoots, stout, upright, dark purple; foliage, very dark green and glossy; leaves, rolled back at tip; pubescence, heavy.

(*b*) Glands usually on blade.

1. *Field*—shoots, purple; foliage, light in colour; leaves, folded back, saucer-like; serrations, very shallow; pubescence, light.
2. *Gueii*—shoots, very stout, upright; foliage, dark green; leaves, thick, slightly folded back; serrations, very broad and shallow; pubescence, heavy.
3. *Monarch*—shoots, stout and upright; leaves, rigid, roundish in shape, folded upwards and slightly waved; serrations, fairly fine and inclined to be sharp pointed; pubescence, heavy.
4. *Shipper's Pride*—shoots, stout and upright; foliage, light in colour; leaves, thick, folded back and waved; serrations, moderately dull and shallow; pubescence, heavy.

PEARS

I—Shoots, Red.

1 and 2. *Clairgeau and Duchess* (a comparison).—Little difference in growth habits and bark characters; Clairgeau leaves are narrower, longer-pointed at the apex, less waved and twisted and with a less reflexed petiole; the surface of older leaves of Clairgeau is more netted than is the case with Duchess.

3 and 4. *Clapp's Favourite and Flemish Beauty* (a comparison)—Both varieties have dark reddish shoots and trunk (a) bark—Flemish is more overspread with grey; lenticels are more prominent. (b) habit—Flemish more spreading; more and finer branches. Clapp's generally has numerous spurs at the base of the head where Flemish would have branches. (c) leaves—Flemish, duller green, surface not netted, smaller and shorter petioled.

5. *Kieffer*—bark brown; lenticels few and small; shoots, reddish brown in colour with brownish pubescence at tip; leaves, dark green, thick and slightly folded; serrations, shallow and bluntly pointed.
6. *Seckel*—bark colour red or tinged with red; lenticels, few and inconspicuous; leaves, thick, mostly flat, small, and often as broad as long; serrations, dull, coarse and shallow.

II—Shoots, green or brownish.

1. *Anjou*—bark, green, well overspread with grey; lenticels, small and not prominent; leaves, long and narrow, often folded and with twisted mid-rib; serrations, dull and shallow.

2. *Bartlett*—bark, green with reddish tinge; lenticels, medium in number and prominent; leaves, usually evenly folded upwards; serrations, shallow, fine and sharp pointed.
3. *Bosc*—bark, green, well overspread with grey; lenticels, medium in number and prominent; branches few and rather fine; older leaves, large, shiny, much reflexed and almost no indication of serrations; younger leaves only irregularly serrated, broad base.
4. *Sheldon*—bark, greenish brown, well overspread with grey; lenticels, medium in number, size and prominence; leaves, long, narrow and well reflexed; serrations, sharp and deep.

SOUR CHERRIES

Montmorency, Early Richmond (a comparison).

1. *Montmorency* is a more upright grower.
2. *Montmorency* has fewer lenticels at the base of its young shoots.
3. The older leaves of Montmorency are dull green in colour; those of Early Richmond are a glossy green.
4. Montmorency usually has two large reniform glands at the base of the blade; Early Richmond has often more than two smaller glands which are more round than reniform and generally situated on the petiole.
5. The pubescence on the young petioles of Montmorency is not as heavy as on Early Richmond.

English Morello.

A spreading grower with nearly orbicular, thick, grey-green leaves, which are very distinct from those of Montmorency and Early Richmond.

SWEET CHERRIES

I—Smooth petioles on young leaves.

1. *Bing*—upright habit; lenticels, few, small and not prominent; buds, short, fairly sharp forming a wide angle; leaves, small and very glossy; tip leaves, dark red; glands, small and irregular in shape.

II—Pubescent petioles on young leaves.

1. *Black Tartarian*—very upright habit; lenticels, fairly numerous and conspicuous; buds, sharp-pointed and fairly sharp-angled; tip leaves, reddish, new leaves dark green; older leaves glossy and slightly rugose; glands, long reniform and rather pale in colour; heavy pubescence on the young petioles.

2. *Elkhorn*—upright habit; lenticels, smaller and less prominent than Schmidtz; buds, medium sharp with a narrow angle; new leaves, light grey-green and quite flat; tip leaves light green; glands, often more than two, widely spread apart but not as much so as Schmidtz; very light pubescence on the young petioles.

3. *Gov. Wood*—upright habit; lenticels, medium in number and fairly inconspicuous; buds, blunt pointed and wide angled; leaves, shiny, rugose and often much folded; new leaves, light green in colour; petioles, dark red in colour; glands, large, reniform and dark red; heavy pubescence on the young petioles.

4. *Lambert*—upright habit; bark, dark in colour; lenticels, fairly prominent and numerous, but small in size; buds, wide angled, but less sharply pointed than Bing; leaves, flat and broad, forming almost a straight line at the base; new leaves, dark green; tip leaves, a green-pink; glands, very large, irregular in shape and often more than two; heavy pubescence on the young petioles.
5. *Napoleon*—Upright habit; lenticels few, medium in size and prominence; buds, fairly wide angled and blunt pointed; leaves, short, broad at base, dull grey-green colour with short stout petiole; glands, fairly large, nearly round in shape, pale in colour and often spread apart; young petioles, stout and very pubescent: tip leaves, a greenish brown.
6. *Schmidtz*—upright-spreading habit; lenticels, numerous, very large, very prominent and light brown in colour; buds, medium sharp pointed and narrow angled; leaves, large, light green in colour, with cordate base which show reddish margins in late autumn; tip leaves, light red; glands on older leaves, usually two, dark red, widely spread apart at the base of the blade; fairly heavy pubescence on the young petioles.
7. *Windsor*—Often sprawly in habit; bark has a distinct reddish cast; lenticels, few and inconspicuous; buds wide angled, long and very sharp pointed; new leaves, dark green in colour; glands, irregular in number and shape; petioles, dark red in colour; heavy pubescence on the young petioles.

Note.—Frequent errors are being made by fruit growers and nurserymen in mistaking Yellow Spanish for Napoleon, Black Eagle for Black Tartarian, Ida for Governor Wood, Schmidtz for Elkhorn, and Schmidtz and Lambert for Bing.

Peaches

I—Scarcity of Yellow Pigment in Leaves (white fleshed).
- (A) Globose glands.
  1. Alexander.
  2. Champion.
  3. Mayflower.
  4. Mountain Rose.
- (B) Reniform glands.
  1. Belle of Georgia.
  2. Carman.
  3. Greensboro.

II—Abundance of Yellow Pigment in Leaves (yellow fleshed).
- (A) Globose glands.
  - (*a*) Leaves very crinkly.
    1. Brigdon (Garfield).
    2. Early Crawford.
    3. Fitzgerald.
  - (*b*) Leaves not much crinkled.
    1. New Prolific.
    2. Niagara.
    3. Reeve's Favourite.
    4. St. John.
    5. South Haven.
    6. Triumph.

(B) Reniform glands.
  1. Admiral Dewey.
  2. Arp Beauty.
  3. Beer's Smock.
  4. Elberta.
  5. J. H. Hale.
  6. Lemon Free.
  7. Rochester.
  8. Yellow Swan.

(C) Intermediate glands.
  1. June Elberta.

The above is merely a classification of peach varieties on certain characters and no varietal descriptions have been attempted that might enable one to distinguish varieties within the various groups. The writer has found it impossible to be certain of the identity of some of these varieties, but at the same time there are other characters which may be made use of in the final identification of varieties. The size of foliar glands is worth considering in some cases, for instance, Rochester has glands which are always much smaller than those of Elberta and J. H. Hale. (See page 31.) The colour of foliage induced by the autumn frosts is quite distinctive of varieties, some becoming quite reddish and others retaining their green colour. The time of leaf fall is of enough importance to warrant the following classification of varieties. These groups are not, however, divided by any clear-cut line.

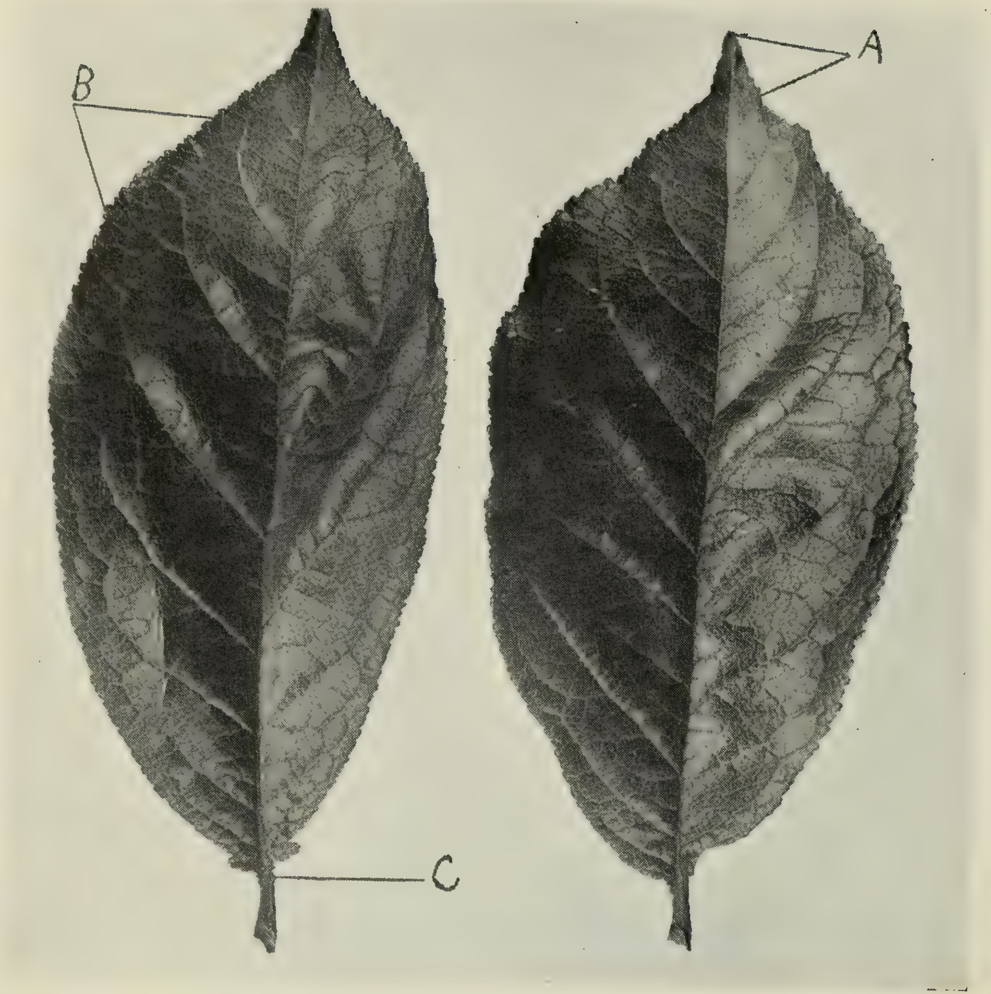
COMPARATIVE TIME OF LEAF FALL IN THE NURSERY

Very Early	*Early*	*Medium*	*Late*
Arp Beauty.	Beer's Smock.	Ad. Dewey.	Alexander.
Greensboro.	Carman.	Champion.	Brigdon.
Yellow Swan.	Early Elberta.	Fitzgerald.	Crawford, Early.
	Elberta.	June Elberta.	Crawford, Late
	J. H. Hale.	Mayflower.	Crosby.
	South Haven.	New Prolific.	Lemon Free.
		Niagara.	Reeve's Favourite.
		St. John.	Rochester.
			Triumph.

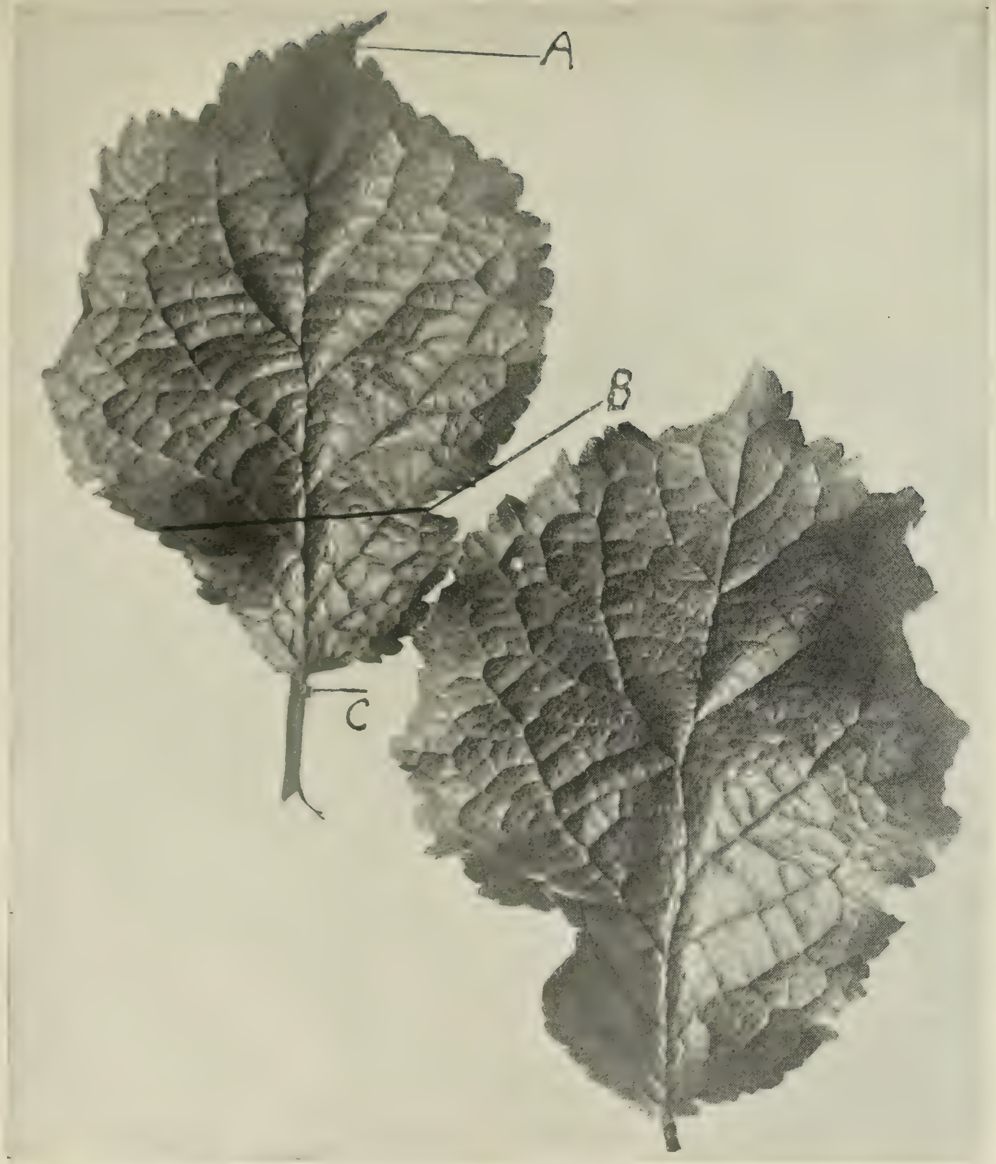
LITERATURE CITED

1. Shaw, J. K., Mass. Agr. Exp. Sta. Bul. 208, 1922.
2. Alderman, W. H., Shoemaker, J.S., Proc. Amer. Soc. Hort. Sci. Rpt. 1925.
3. Grubb, N. H., Jour. Pom. & Hort. Sci., Vol. III, No. 1, Nov. 1922.
4. Winter, J. D., Proc. Amer. Soc. Hort. Sci. Rpt. 1925.

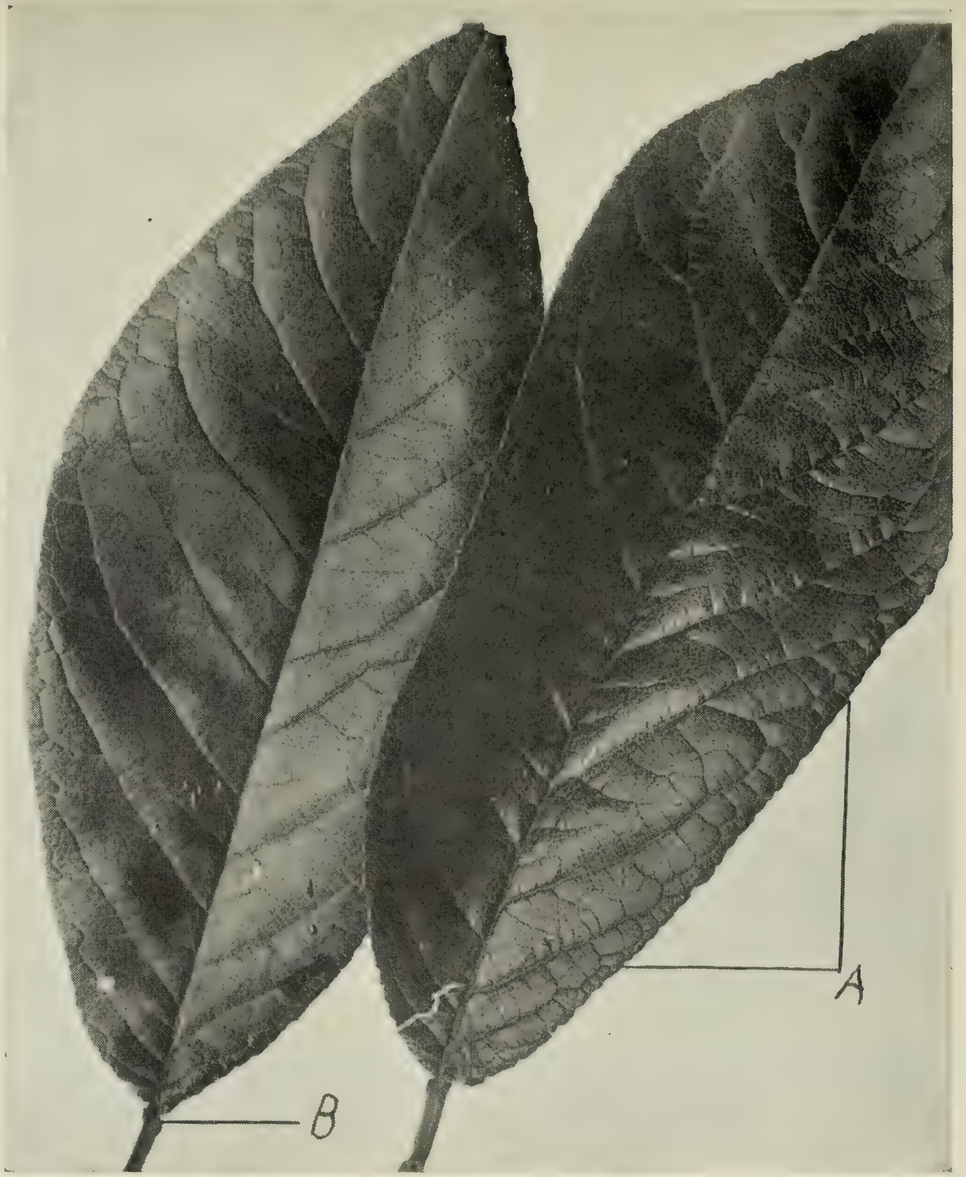
PLUMS



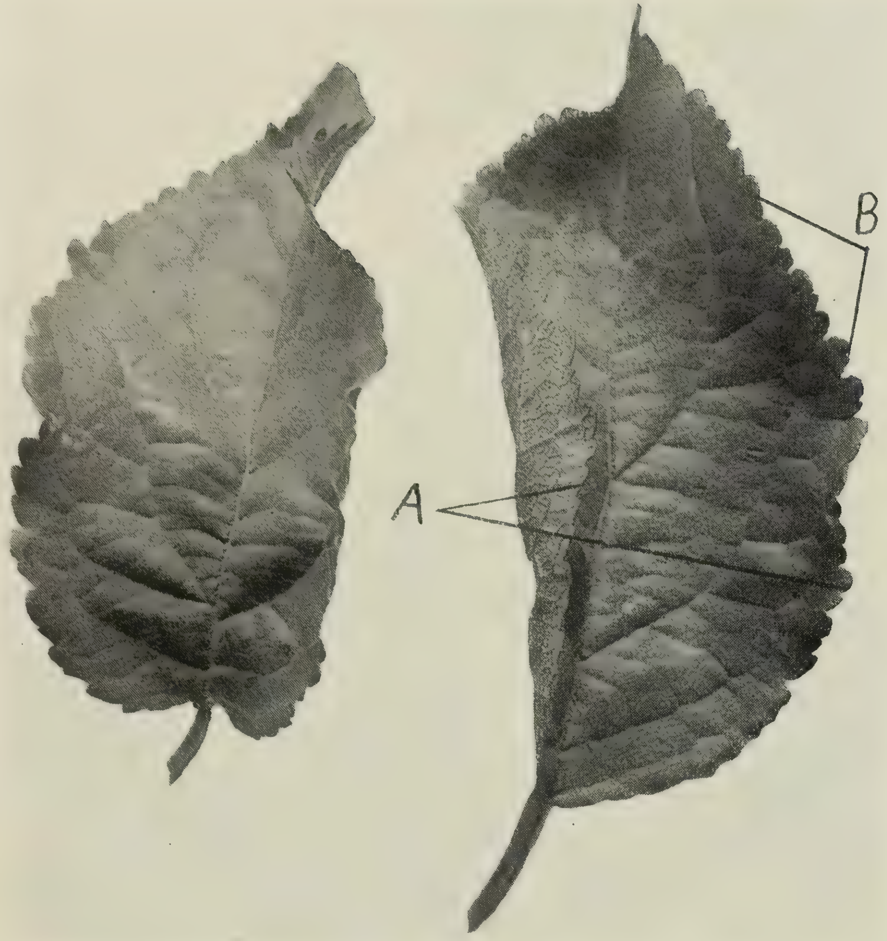
ABUNDANCE.—A. Tip fairly abrupt; B. serrations fine, irregular; C. glands several, small, mostly on petiole.



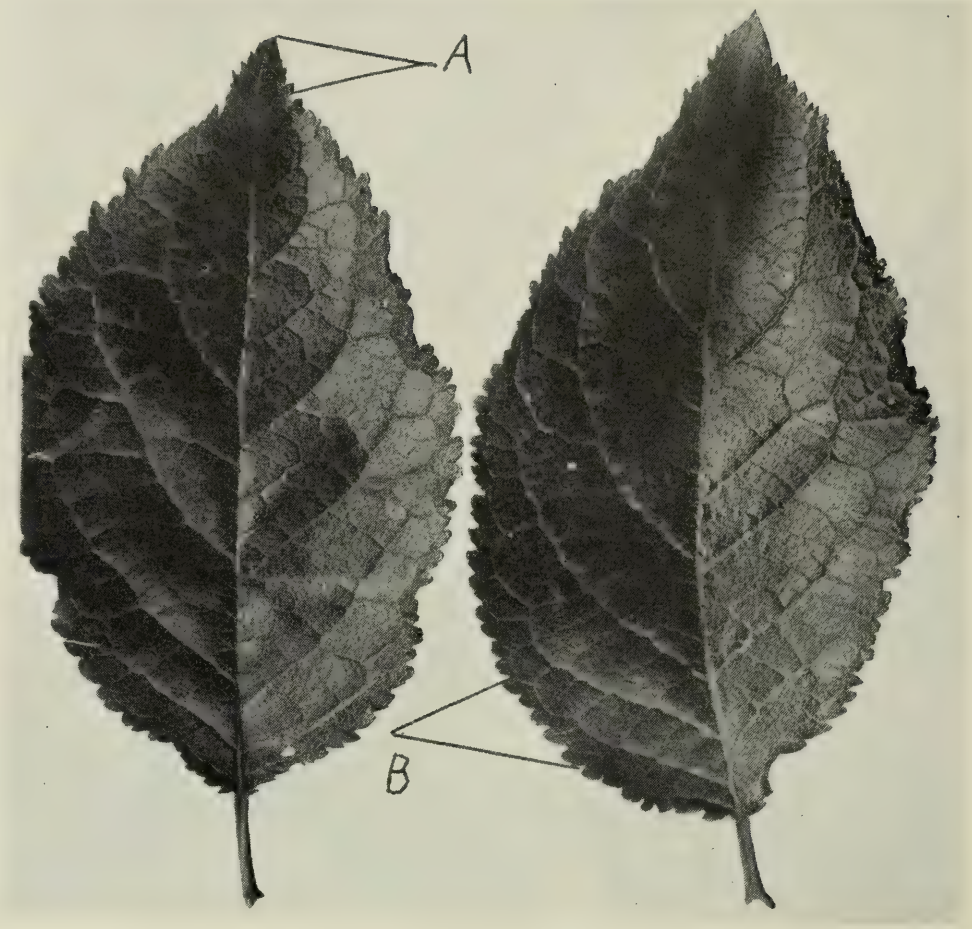
BRADSHAW.—A. Midrib often twisted. B. Folded back and waved; C. Glands usually on petiole.



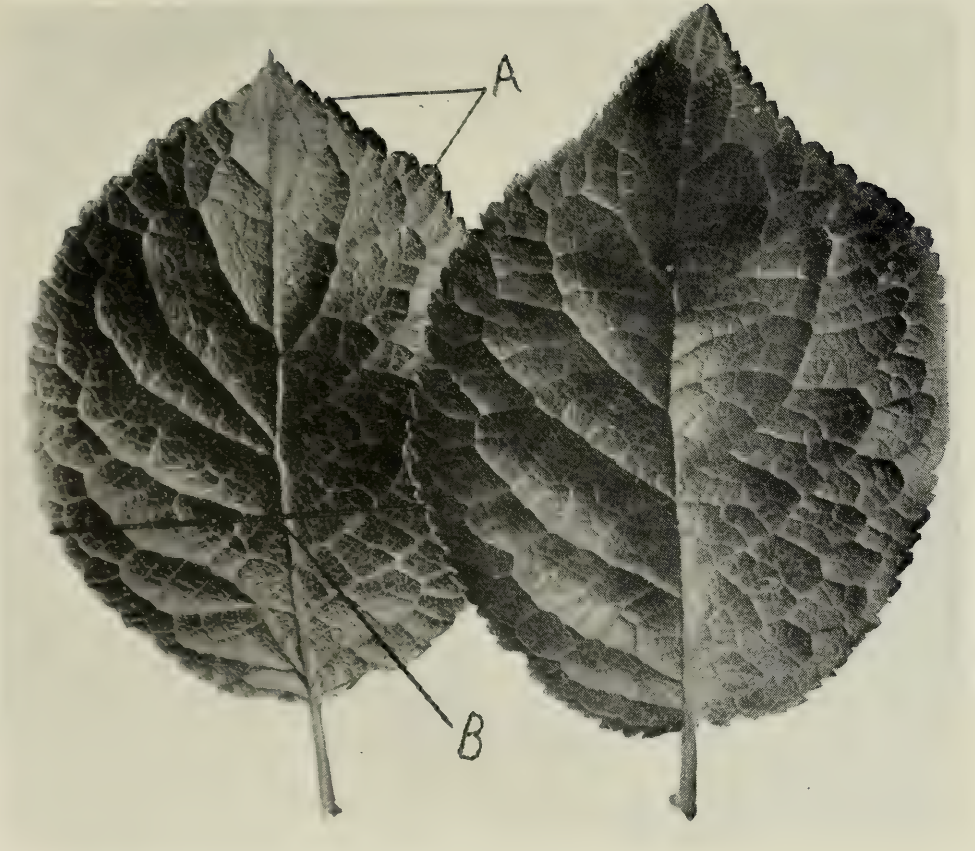
BURBANK.—A. Serrations fine, shallow, irregular; B. Glands several on petiole.



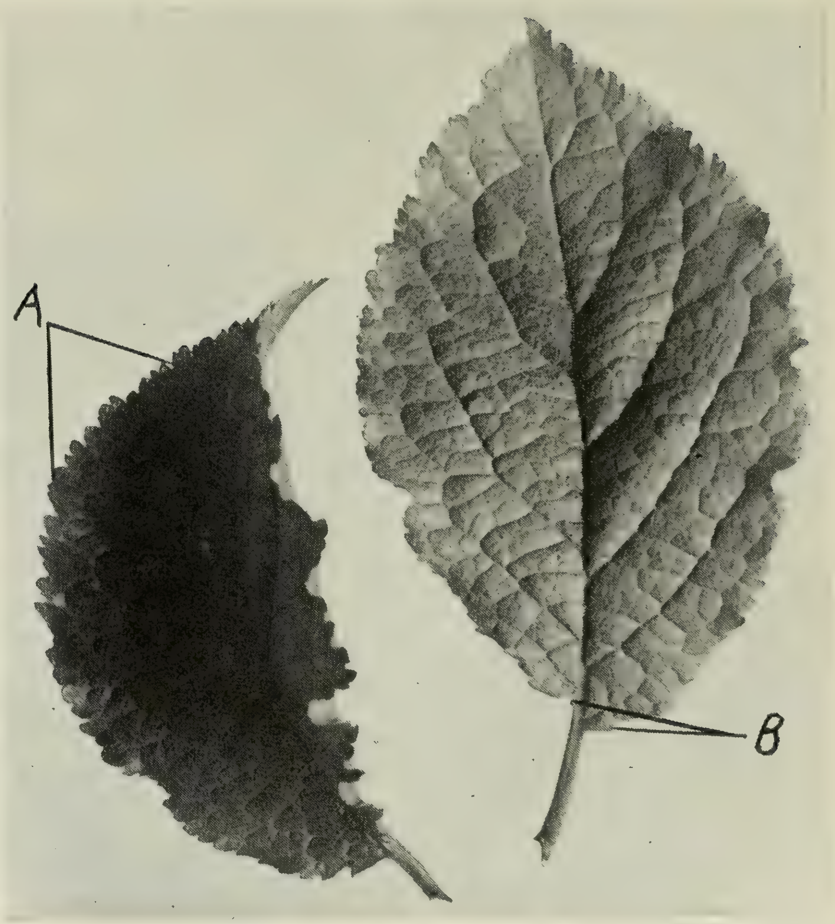
Coe's Golden Drop.—A. Folded upward. B. Serrations, coarse.



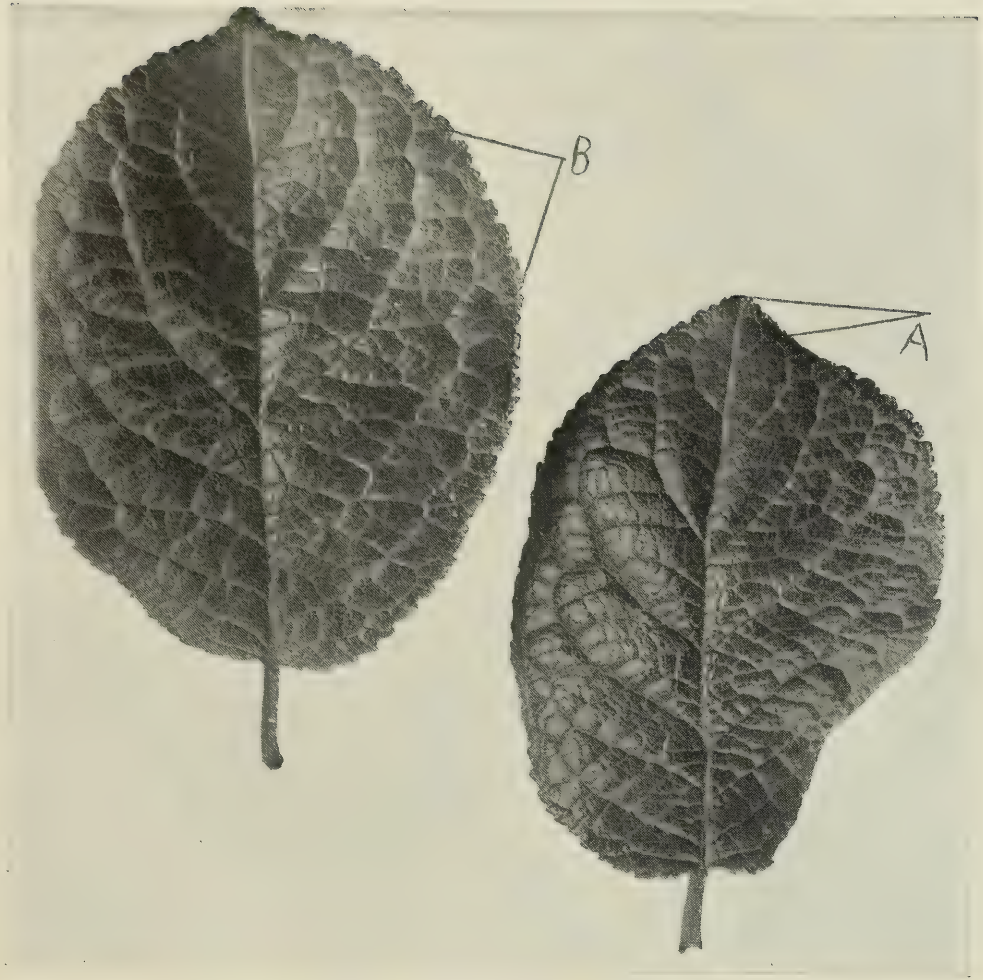
Fellenburg.—A. Serrations at tip serrate in nature. B. Serrations at base deep and blunt.



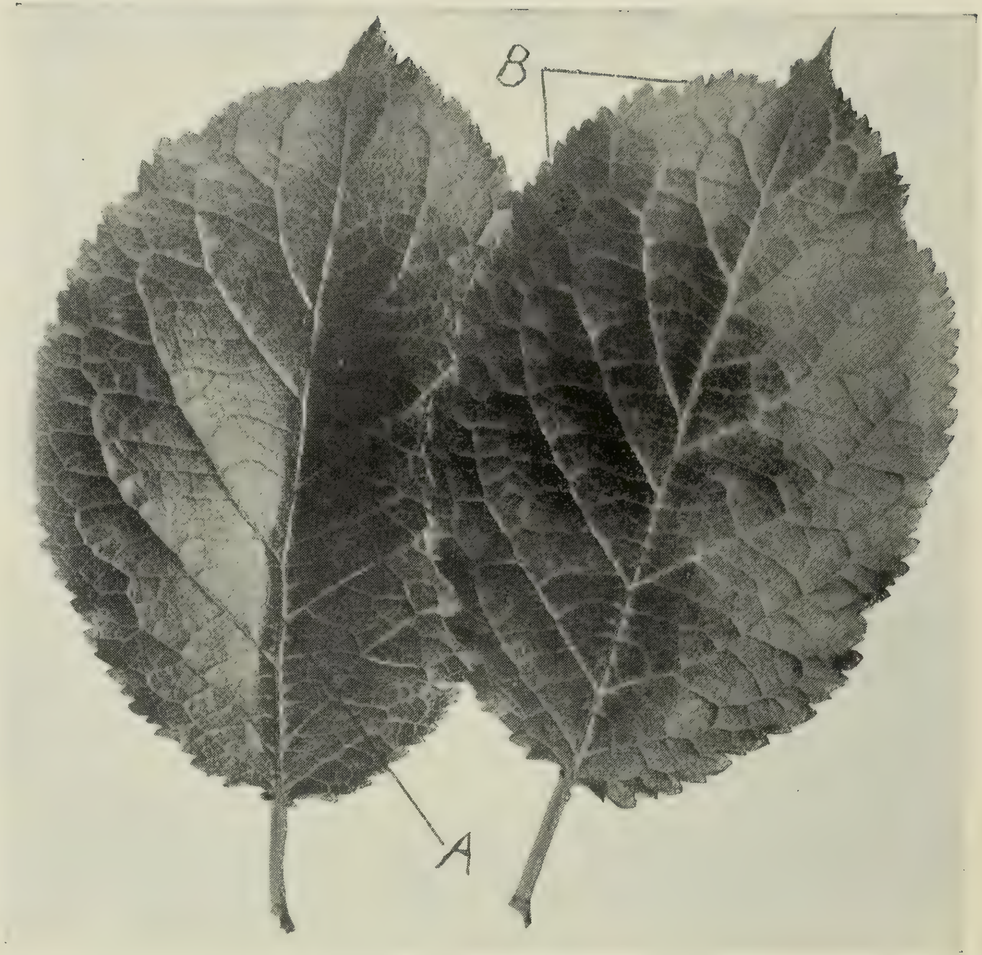
FIELD.—A. Serrations coarse and shallow. B, leaves folded back, saucer-like.



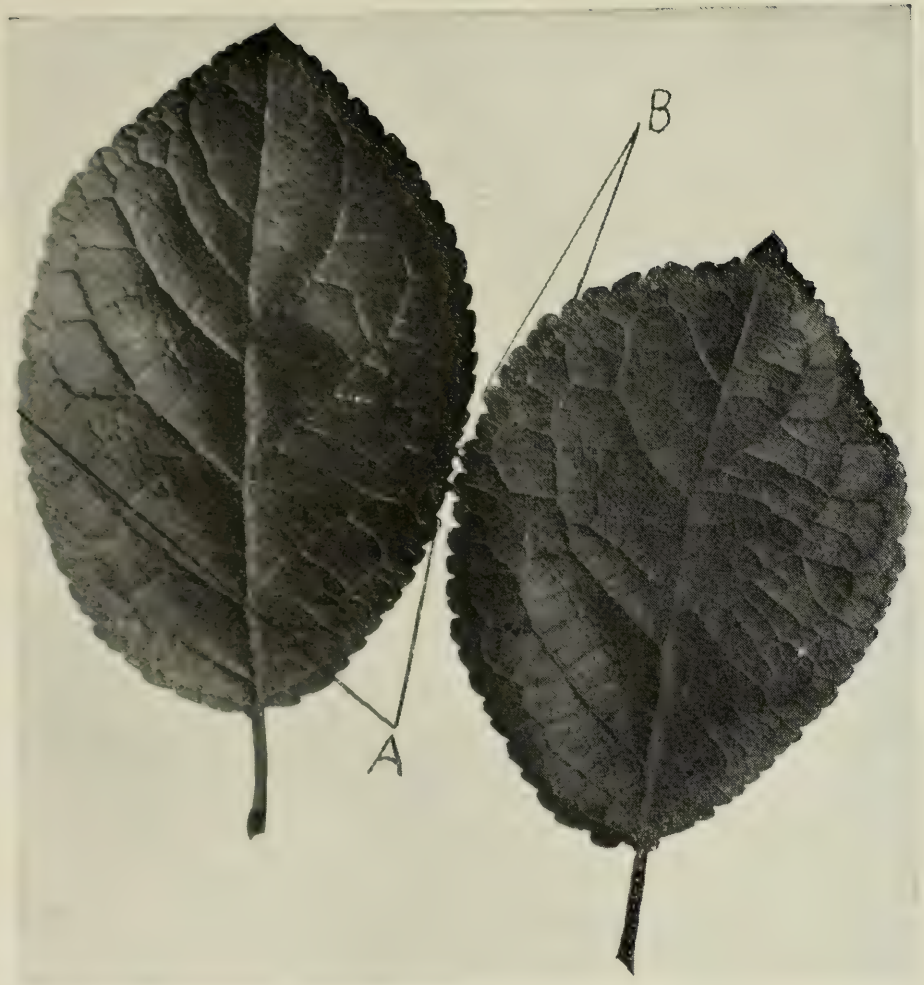
GERMAN PRUNE.—A. Serrations fairly sharp, deep and irregular. B. Glands small, usually on blade.



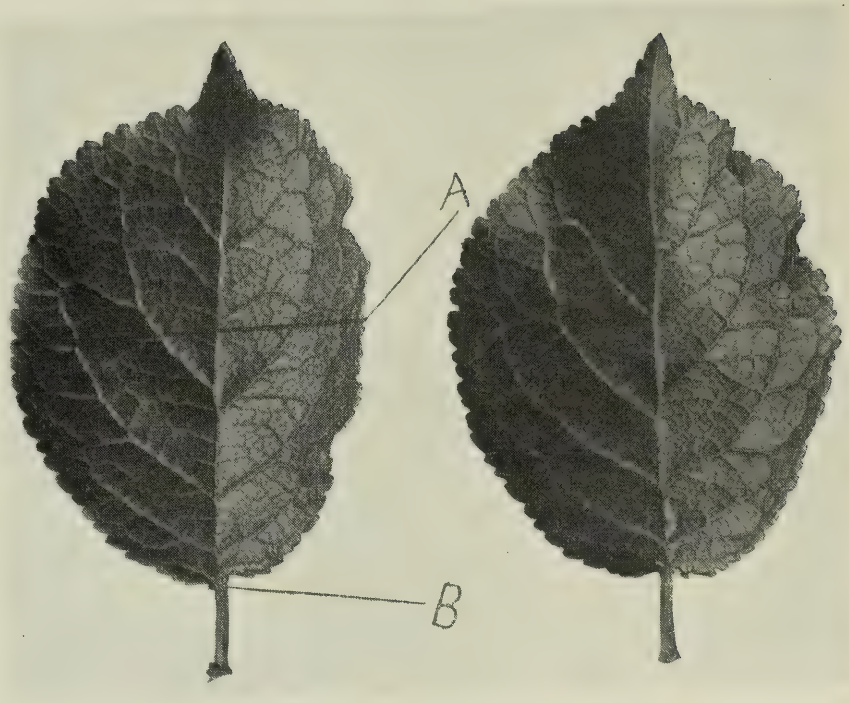
Glass.—A. Tip rolled back. B. Serrations quite shallow; leaves glossy.



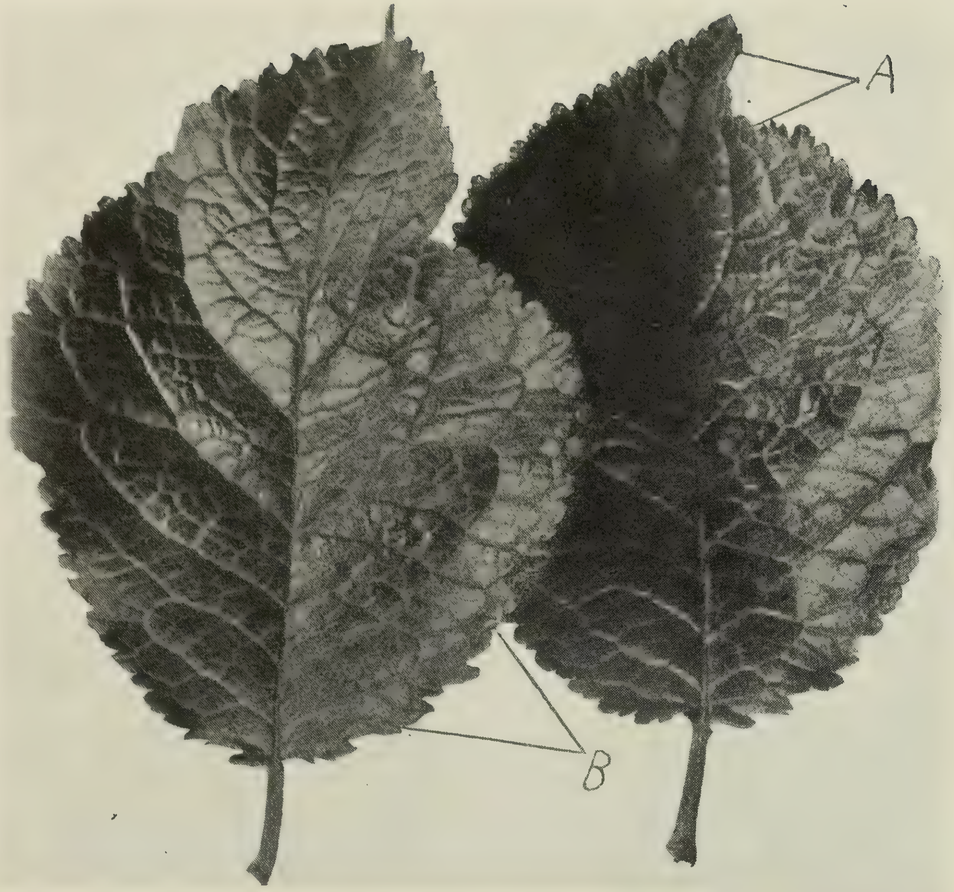
Grand Duke.—A. Midrib reflexed. B. Serrations fairly sharp and shallow.



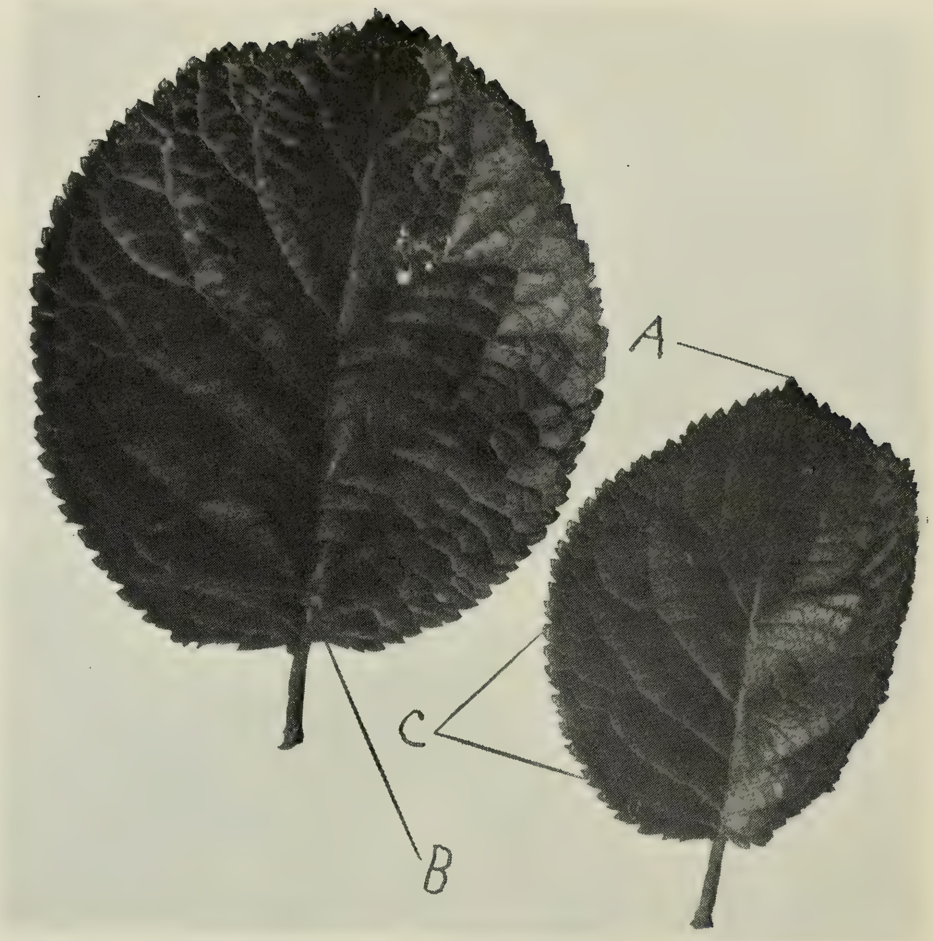
Gueii.—A. Slightly folded back. B. Serrations broad, dull and shallow.



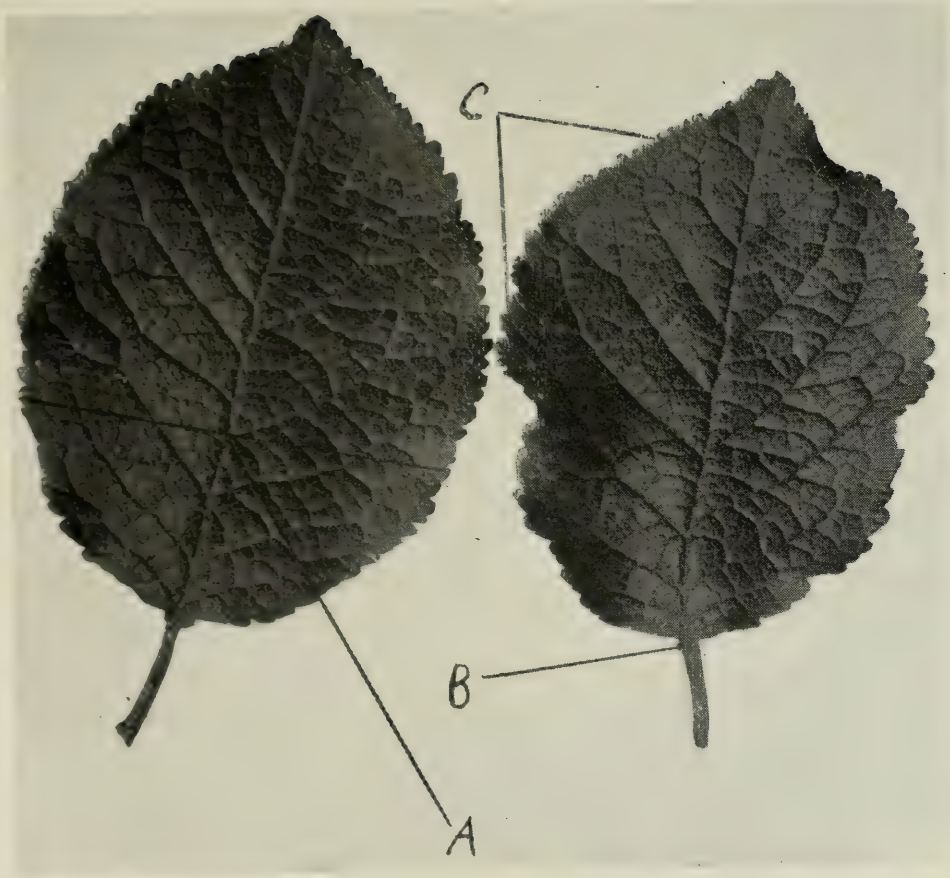
Imperial Gage.—A. Folded upward. B. Glands, on petiole, small, round with depressed centre.



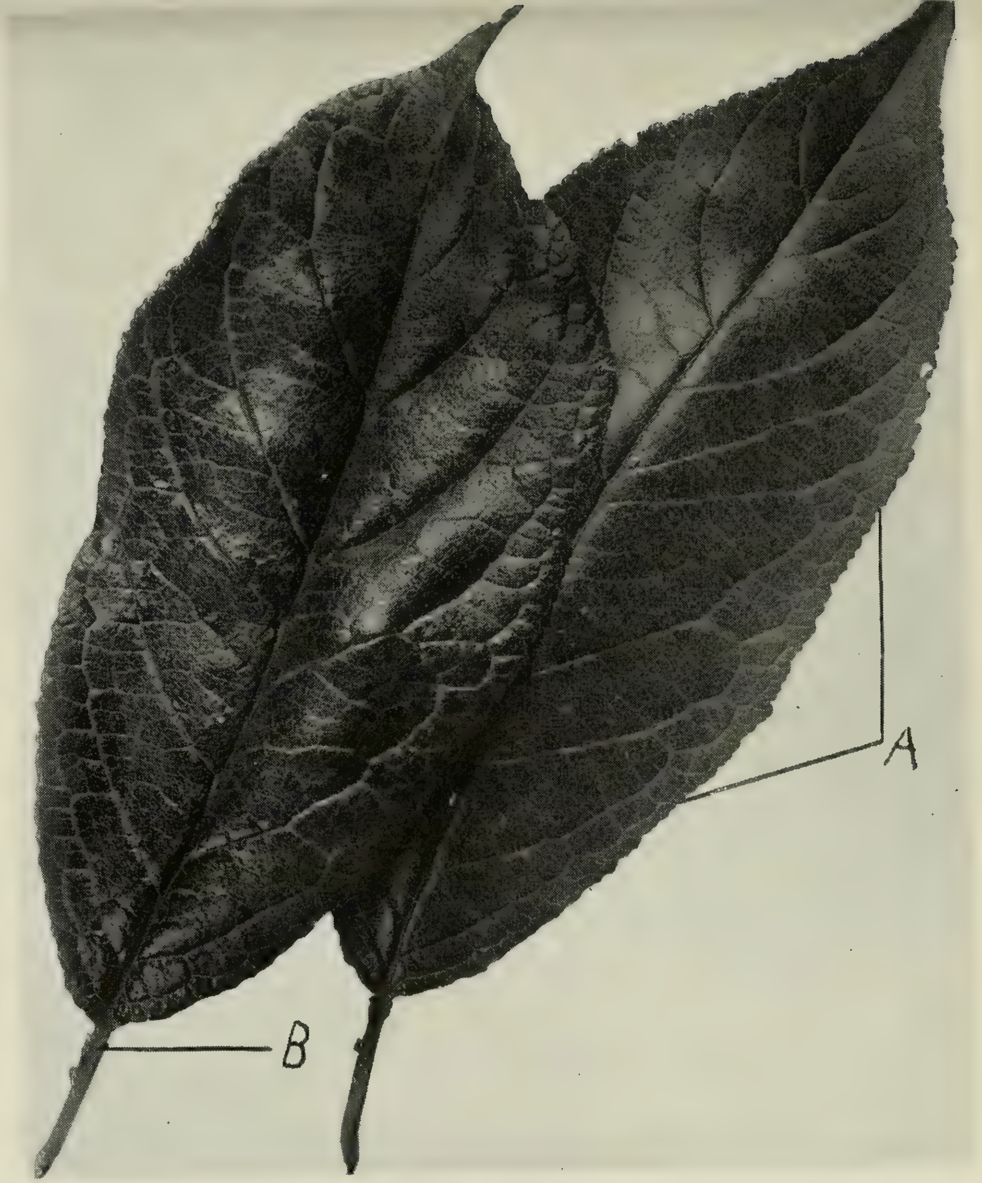
LOMBARD.—A. Margin often deeply waved. B. Serrations irregular and fairly deep.



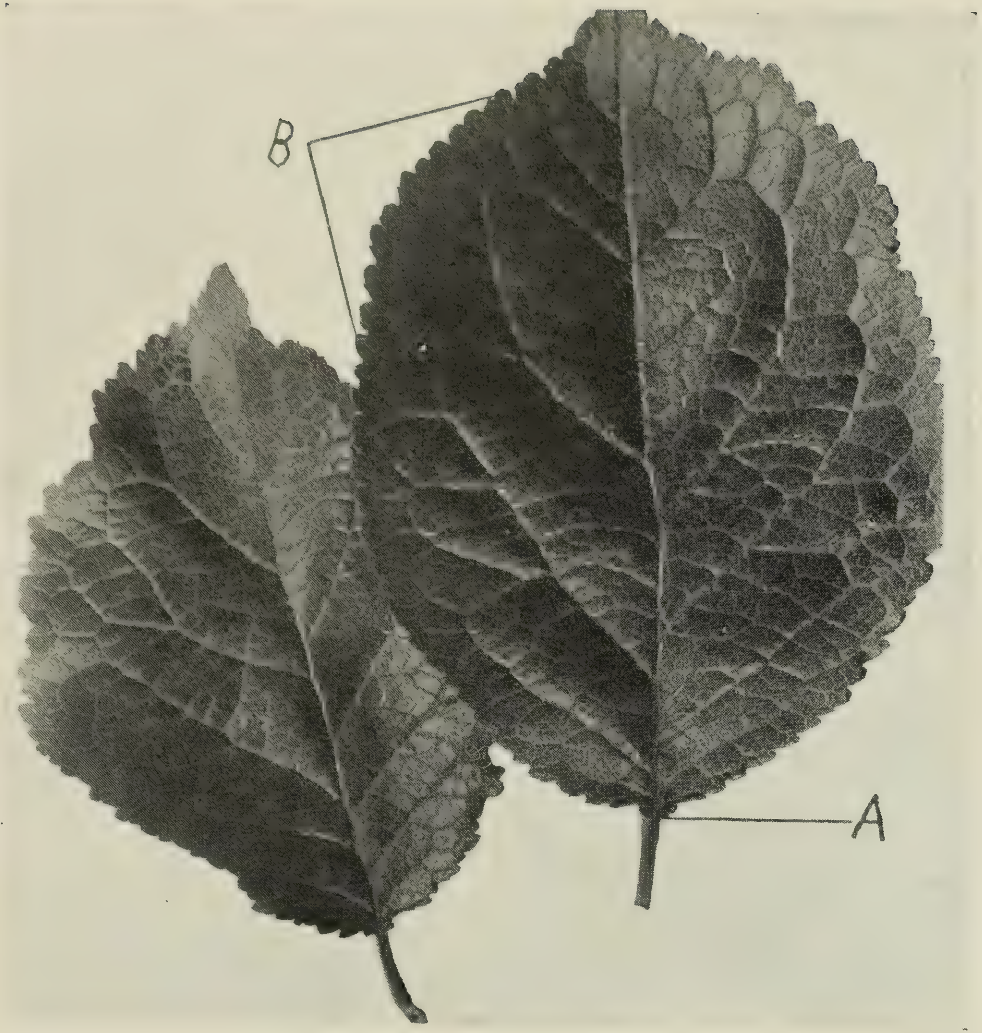
MONARCH.—A. Very short tip. B. Broad base. C. Serrations shallow, inclined to be sharp pointed.



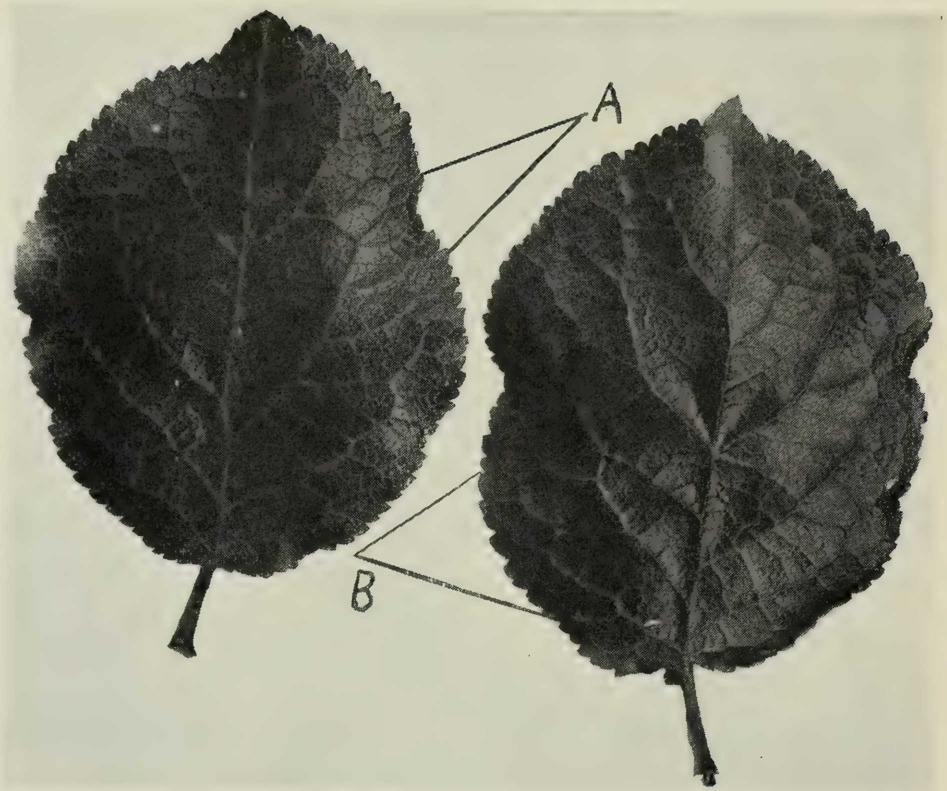
Pond.—A. Folded back. B. Glands usually on petiole. C. Serrations shallow.



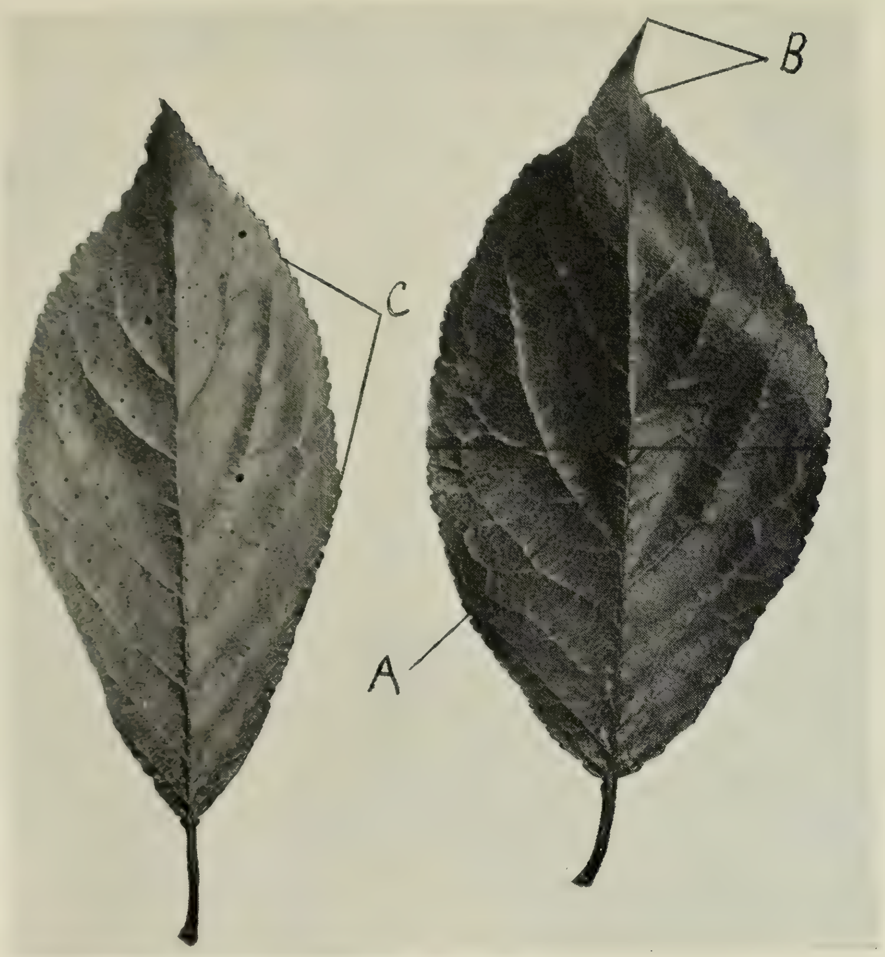
Red June.—A. Serrations dull and shallow. B. Glands more than 2; leaves glossy.



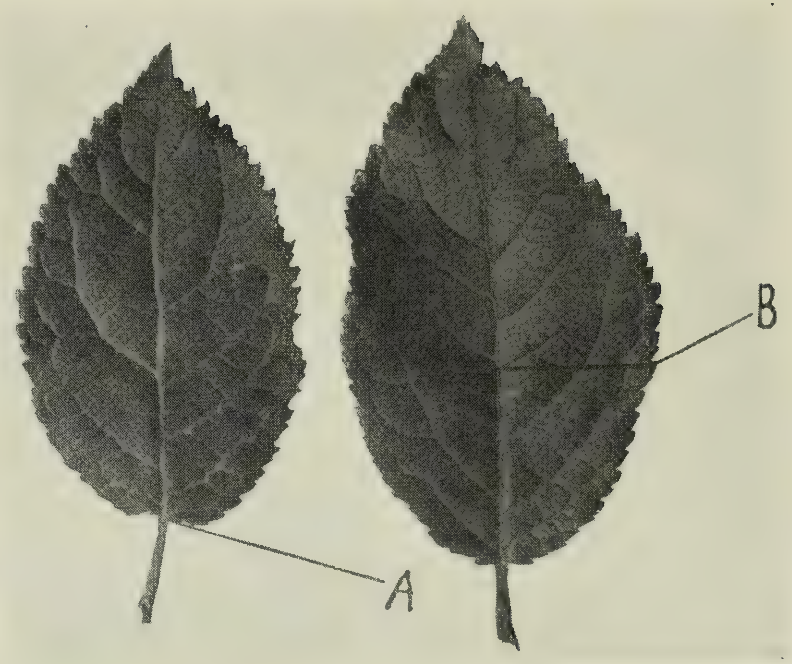
Reine Claude.—A. Glands large. B. Serrations blunt, fairly shallow, sometimes double.



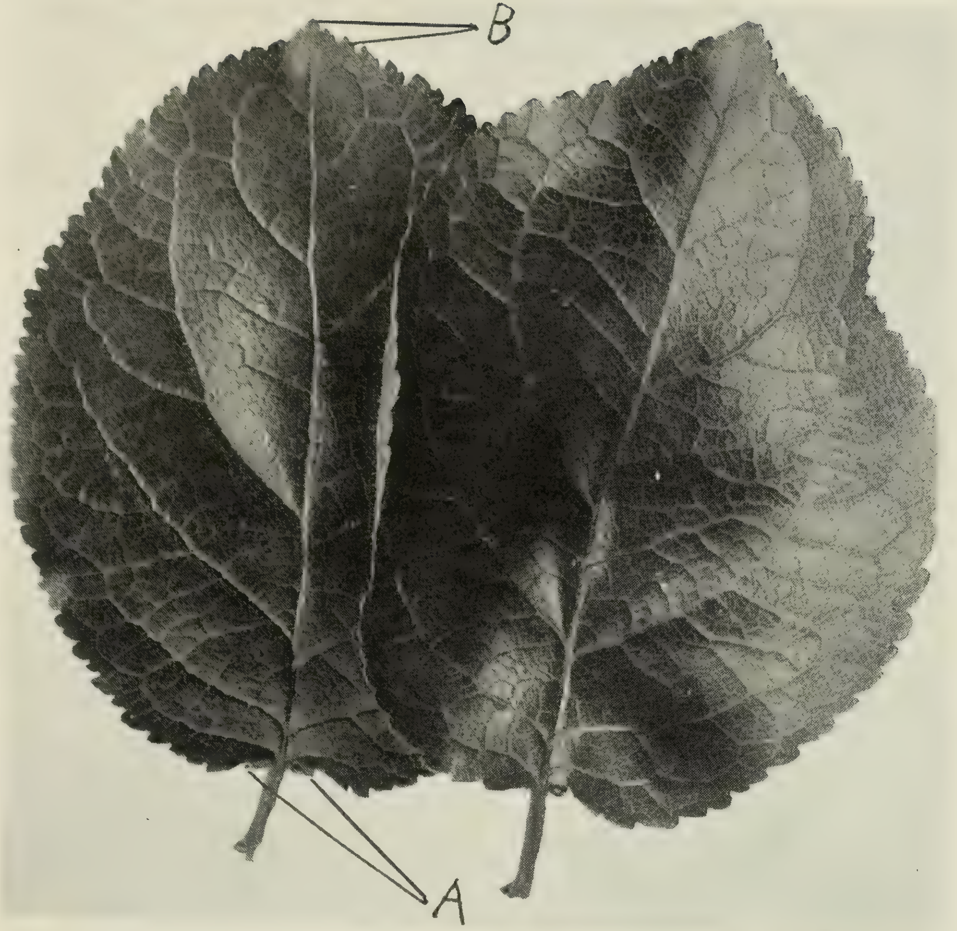
Shipper's Bride.—A. Broadly waved. B. Serrations moderately dull and shallow.



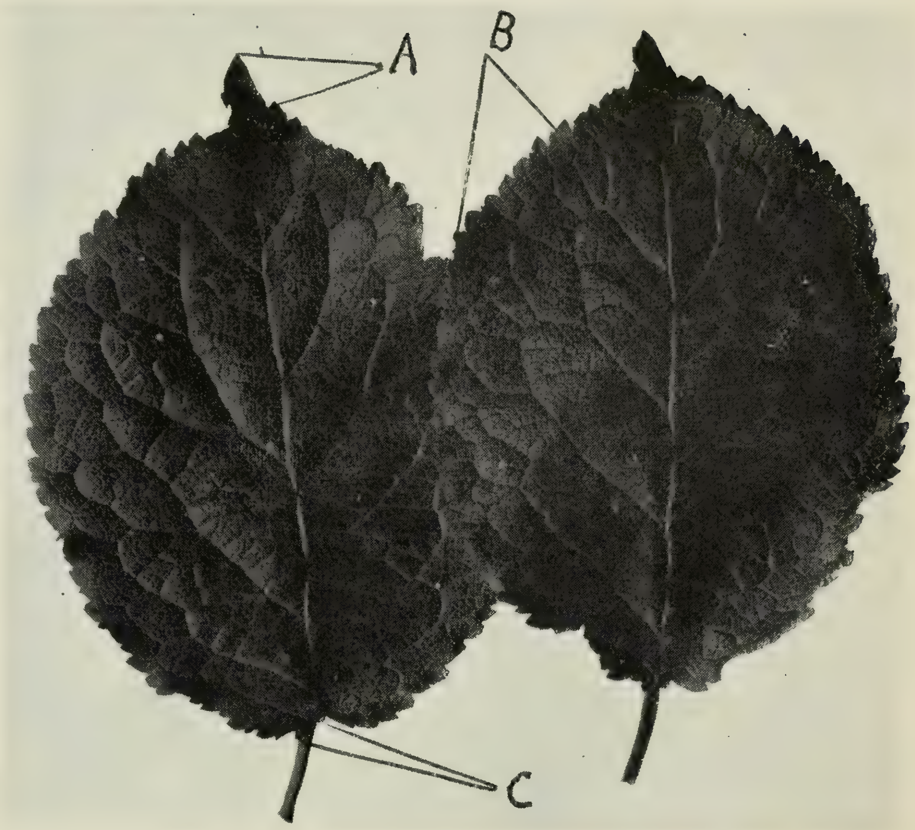
SHIRO.—A. Leaves nearly flat. B. Tip long and often abrupt.
C, Serrations shallow and fine.



SHROPSHIRE DAMSON.—A Glands small, usually on blade.
B. Leaves nearly flat.

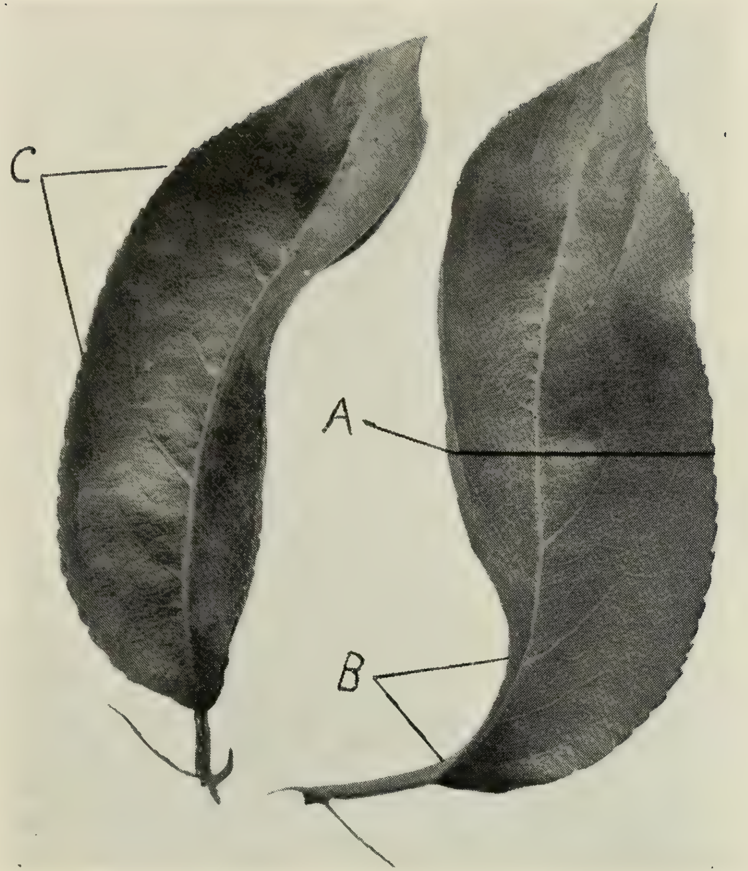


Washington.—A. Glands on blade, widely spread apart.
B. Tip very short.

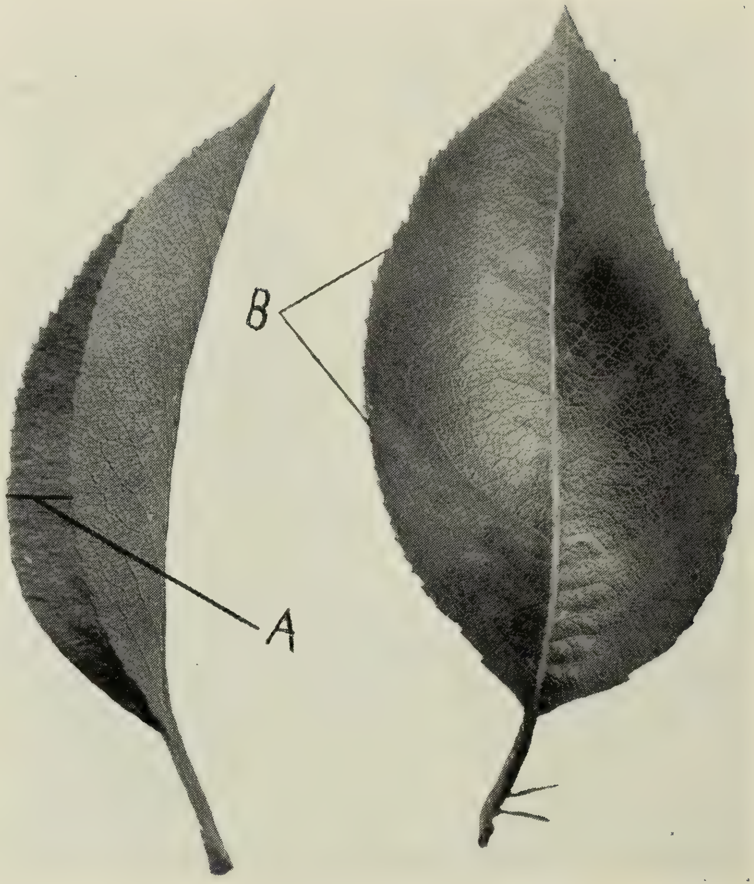


Yellow Egg.—A. Tip abrupt. B. Serrations shallow and fairly sharp.
C. Glands usually on blade.

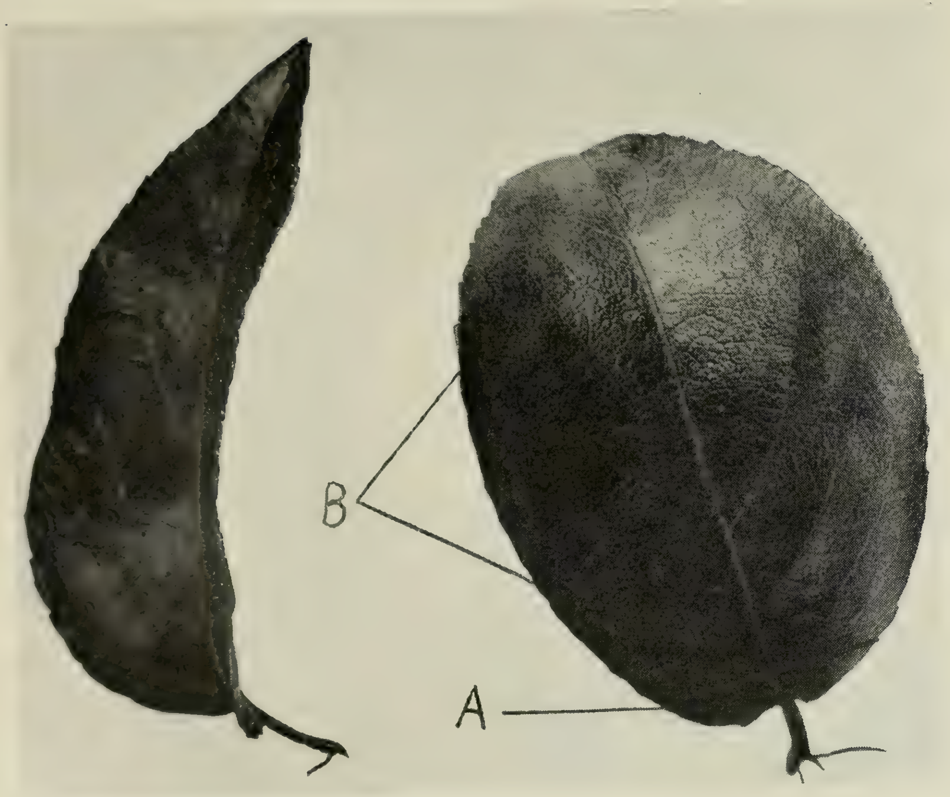
PEARS



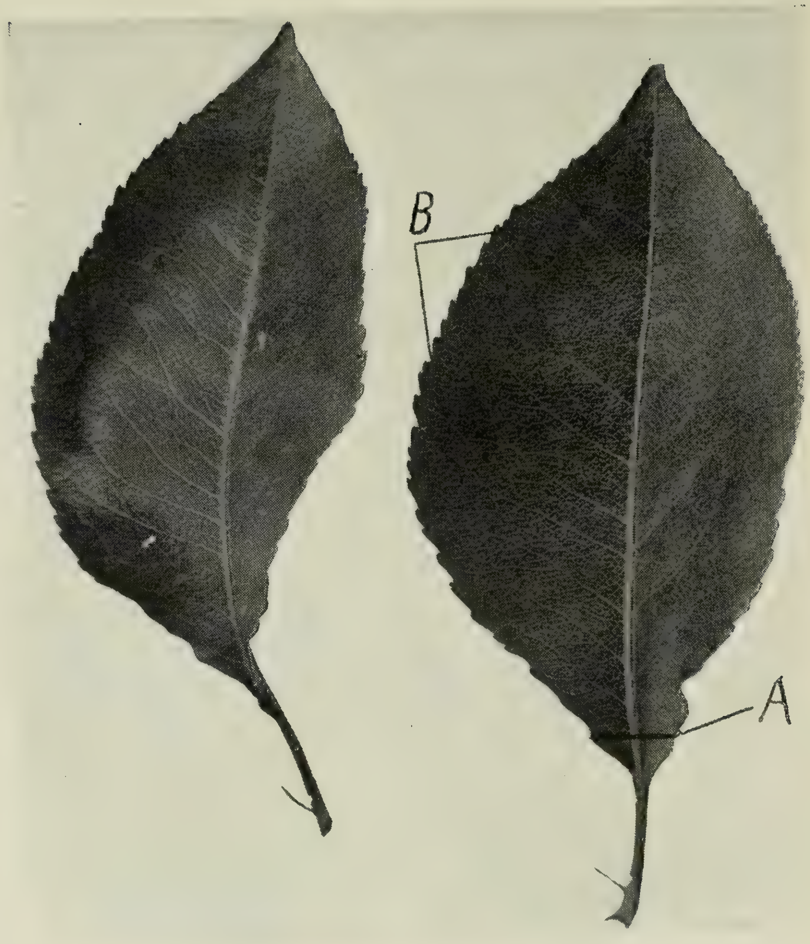
ANJOU.—A. Folded upward. B, Twisted midrib.
C. Serrations dull and shallow.



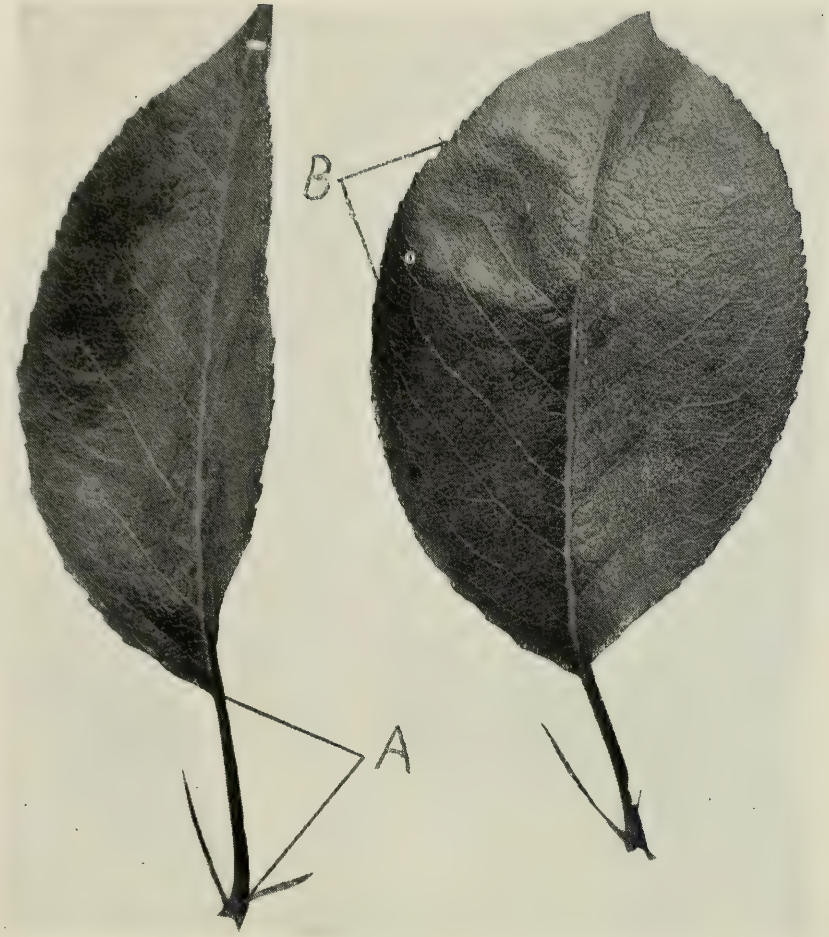
BARTLETT.—A. Evenly folded upward. B. Serrations
shallow, fine and sharp pointed.



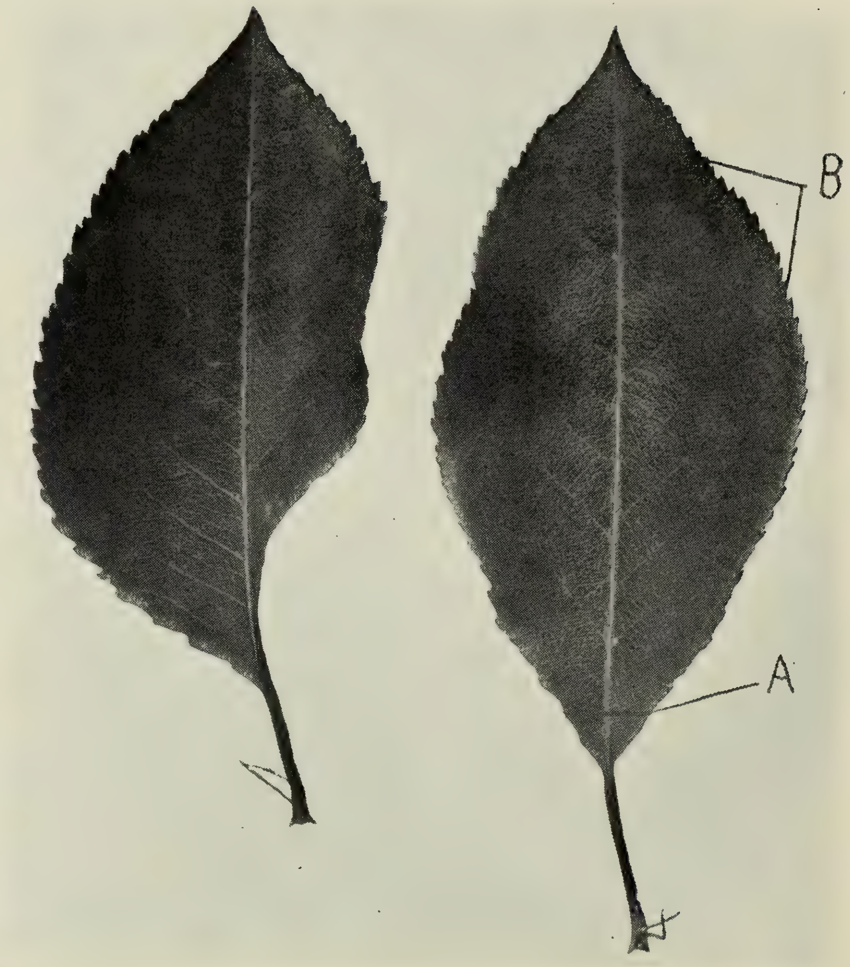
Bosc.—A. Broad base. B. Serrations often indistinct.



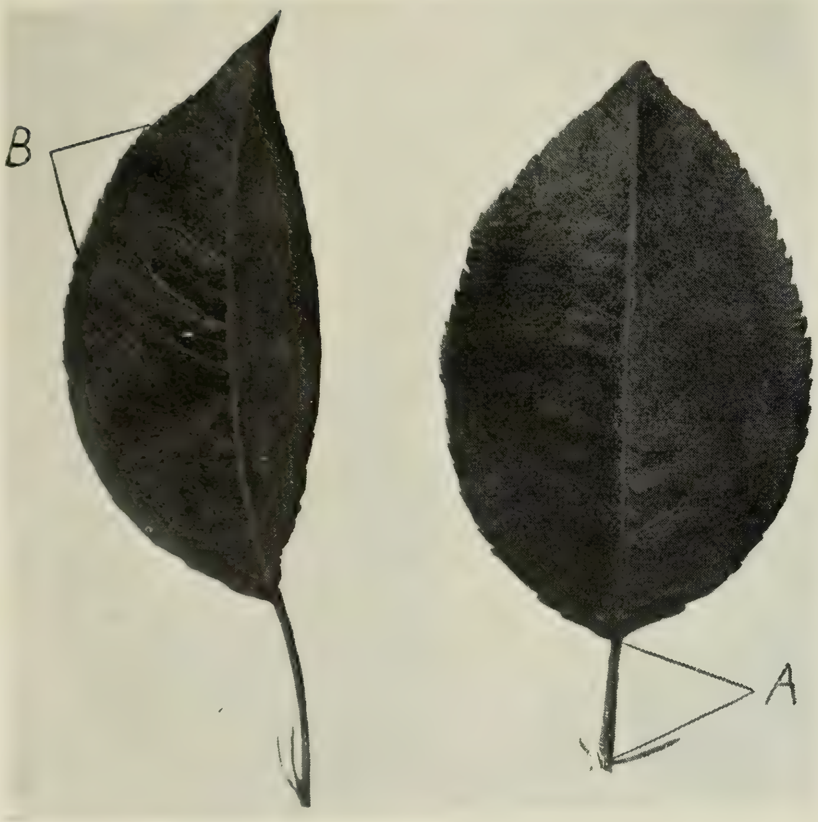
Clairgeau.—A. Fairly narrow base B. Serrations shallow.



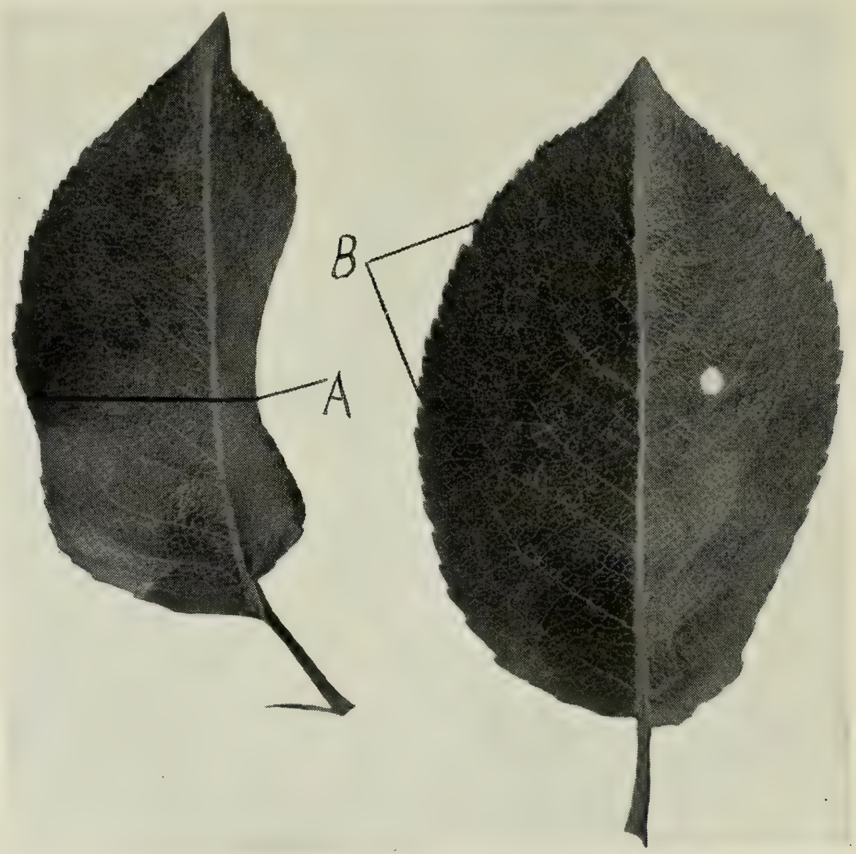
Clapp's Favourite.—A. Petiole fairly long. B. Serrations shallow, surface glossy and netted.



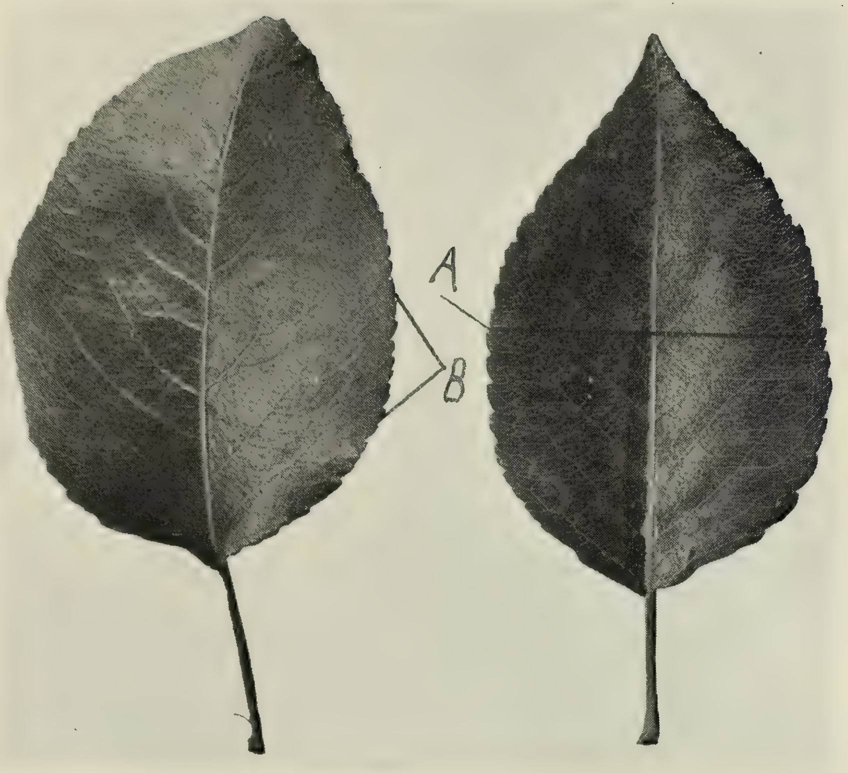
Duchess.—A. Narrow base. B. Serrations moderately shallow.



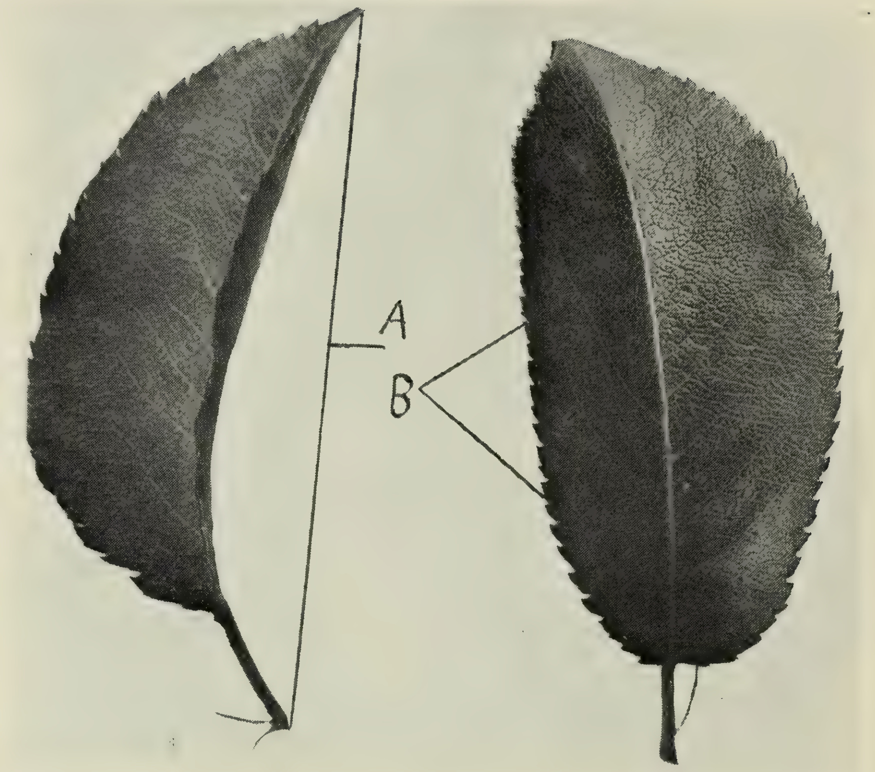
FLEMISH BEAUTY.—A. Comparatively short petiole. B. Serrations quite shallow; surface dull, smooth.



KIEFFER.—A. Slightly folded. B. Serrations shallow and bluntly pointed.

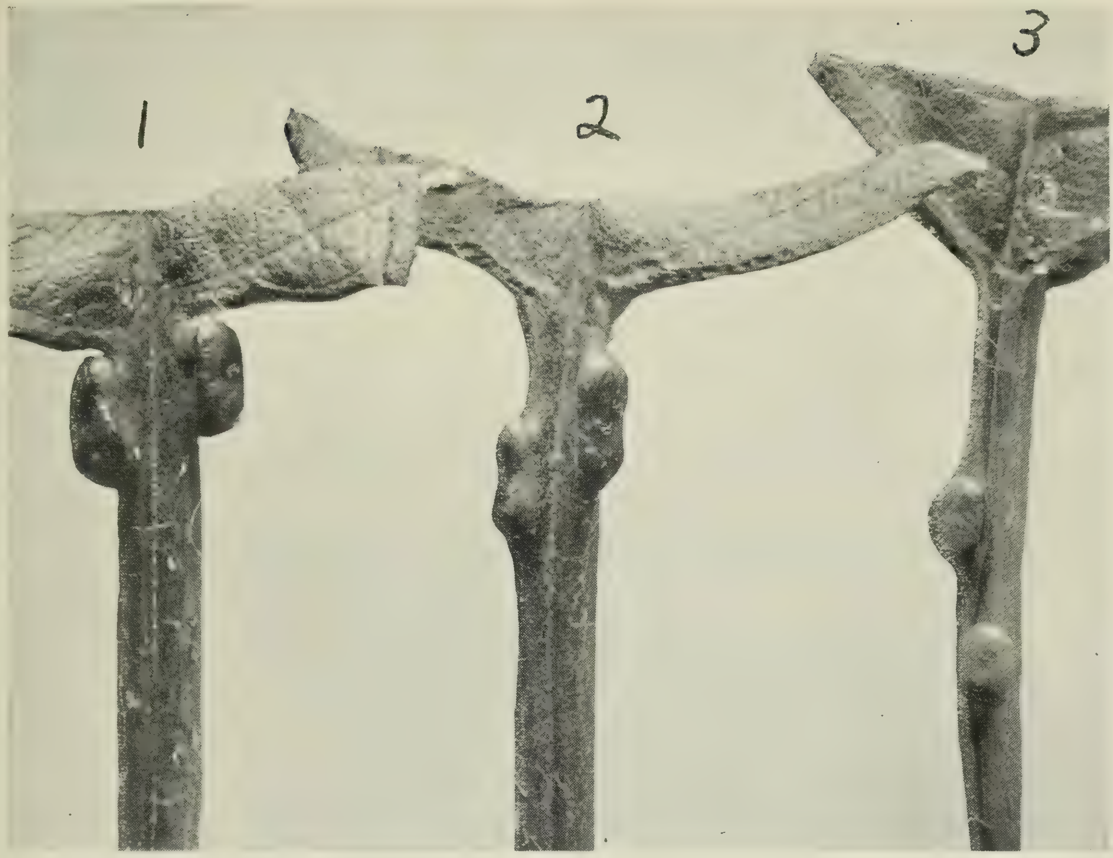


SECKEL.—A. Mostly flat. B. Serrations blunt and shallow.

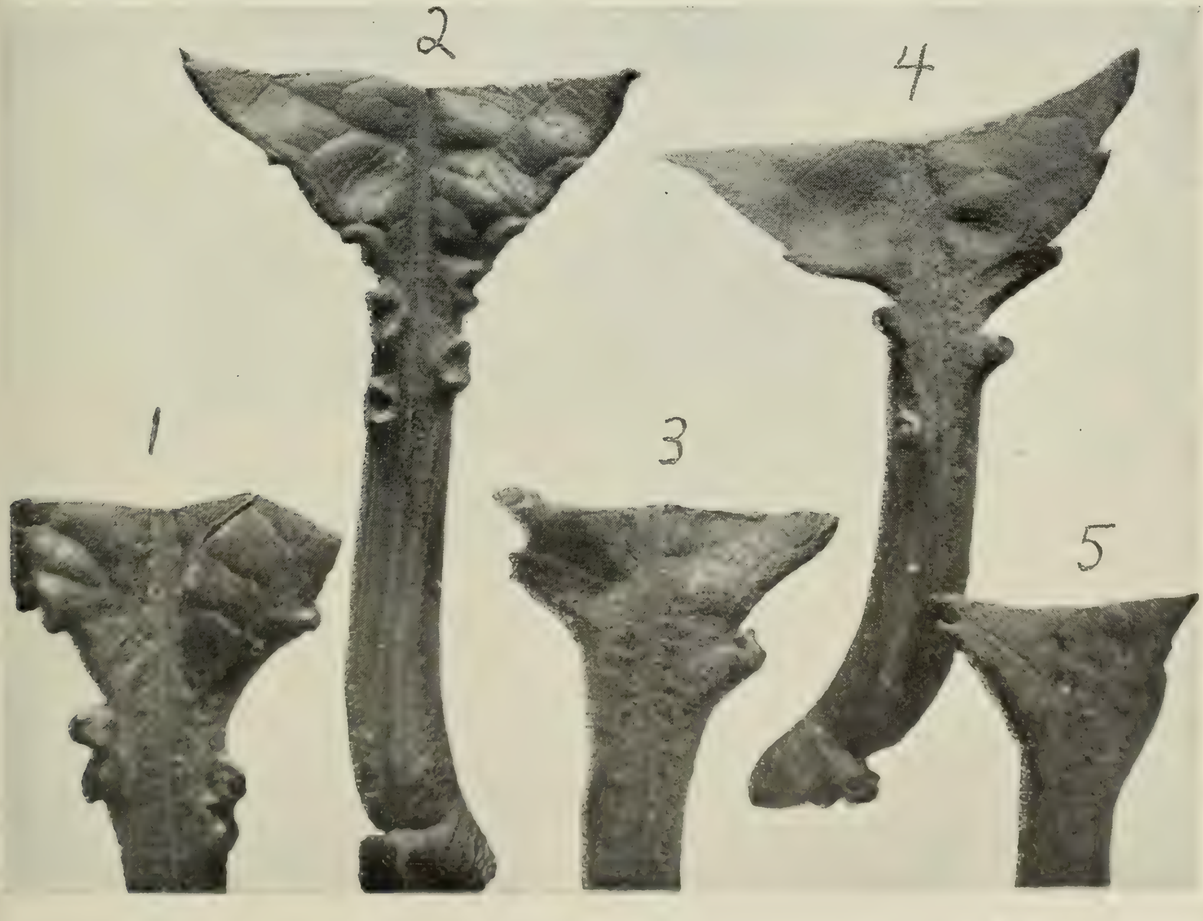


SHELDON.—A. Midrib well reflexed. B. Serrations deep and fairly sharp.

CHERRIES and PEACHES



Foliar Glands of Sweet Cherries (x8)—1. SCHMIDTZ. 2. BLACK TARTARIAN. 3. YELLOW SPANISH.



Foliar Glands of Peaches (x8)—1. ELBERTA. 2. ROCHESTER. 3. JUNE ELBERTA. 4. ST. JOHN. 5. A glandless variety.

BULLETIN 320] [JULY, 1926

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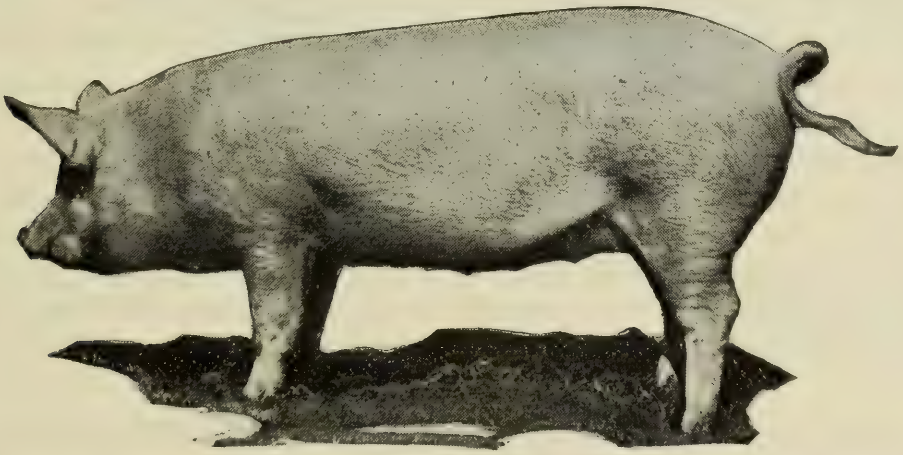
THE BACON HOG

BREEDING, GROWING AND FINISHING

By Wade Toole, B.S.A., M.S., and R. G. Knox, B.S.A.
Department of Animal Husbandry.

Canada must produce bacon hogs or lose the export trade which makes profitable pork prices, and Ontario must continue to be the leader in bacon production in Canada. War-time prices, based upon an abnormal demand for meats of all kinds, with off type hogs going at the same price per pound as hogs of approved conformation and finish, had a very detrimental effect upon hog breeding operations. Breeders were not so careful in the selection of their breeding stock. Neither did they market at the best weights. Consequently, in so far as high-class Wiltshires were concerned, much ground was lost during and after the war. In so far as quality and uniformity of bacon is concerned, we dropped back several decades. Conditions changed rapidly at the close of hostilities, and Canada must face the keenest competition on the world's markets. Denmark, our strongest competitor, was almost driven out of the hog business by 1918, but is now stronger than ever and with uniformity and qualify of product as well as bulk. Lard hogs may be produced at less cost in the States to the south than in this country. Cheap corn makes fat hogs at low cost. Ontario is a barley and oats province, and has the supplements



A Select Hog.

Note the length of side, smoothness throughout, trimness of jowl and underline, and uniformity of depth.

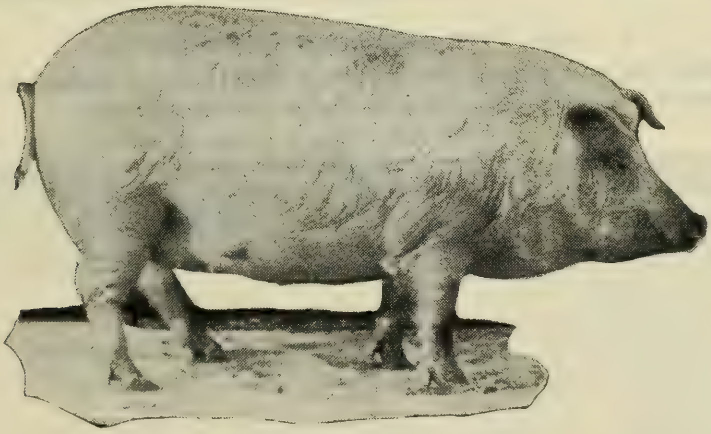
necessary to make the highest quality of bacon. Great Britain pays a premium for the long, lean bacon hog and Britain is our market. Hog prices during the past few years have ranged around two dollars per hundredweight higher in Ontario than on the Chicago market. This is in part due to the fact that lard has been brought down in price by the enormous quantities of vegetable oils on the market, and the lard hog loses so much of his weight in fat trimmings that he is not worth as much as the more muscular bacon hog. But it must also be remembered that the demand for bacon on the British market also makes for extra money in the pockets of the Ontario hog producers. Our slogan should be: Breed the Bacon Hog.

What is the Bacon Hog?

Without going into an exhaustive discussion of breeds, it might be well to consider type. Breed tests often show that there is more in type than in breed. It should, however, be understood that breeding counts, and no breeder is well advised to attempt to make over breeds when others are already established for the certain purpose he desires. Suffice it to say that in the production of export bacon best results are likely to follow the breeding of the right type of Yorkshires, Tamworths and Berkshires. It may be possible to make bacon out of Durocs, Polands, Chester-Whites and the dual-purpose Hampshires, but breeders will lose years of market profits in remaking breeds at first constituted for other purposes. It should be remembered, too, that not all Yorkshires are good bacon hogs, neither do all Tamworths make good Wiltshires, and only the long, smooth type of Berkshires get by in the "select" class. Hogs may now be sold on a graded basis, giving the producer a premium for the right kind. During the first six months of grading in Canada, only 13.3 per cent., or one hog in every eight of the 527,626 offered, graded select. The average in Denmark is 80 per cent. At the present time around 25 to 26 per cent. of the hogs marketed on Toronto market go in the "select" class. This percentage must be increased, and it is the object of this bulletin to aid in this direction.

While a large percentage of the hogs marketed in Ontario are not properly bred, many which are bred right are spoiled by improper care and finish. We must not only learn type but finish. However, type is the foundation and breeding largely controls this factor. For strictly bacon type the packer likes the Yorkshire first, the Tamworth second and the Berkshire third, but there are good and bad in all these breeds, and anyone having the type that grades "select" need not discard his breed even though it may not be the most popular. However, it is good policy, particularly for the beginner, to produce what the market wants.

The bacon hog should be long and smooth, with a nicely arched back and a straight, trim and neat underline. Length without smoothness and finish does not make a desirable hog, neither does smoothness and finish without length. The jowl and shoulder should be light and smooth, showing no flabbiness in the former and no coarseness or openness in the latter. Heavy jowls generally go with thick, fat or coarse hogs. Heavy shoulders throw the side out of balance, too large a percentage of the cuts coming from this comparatively cheap end of the carcase. The neck should be light, not too long and yet not too short and thick. The back, from neck to tail, must be evenly and well fleshed. Good bacon hogs are not razor-backs. The side should be long and flat, carrying even with the shoulder and ham, of medium depth dropping straight from the back. No round-ribbed hogs can get in the select class. The rump should round off even with the arch of the back and should show no surplus fat at the tail head. The ham should be fairly full yet tapered nicely down to the hock. The bone should be clean and strong, and the body should show no tendency to wrinkle. The belly should be trim and neat, and the whole body should show that muscular tendency which denotes lean meat rather than fat. The pig must be finished but not over fat, and should weigh, at the market, 170 lbs. to 220 lbs., or 180 lbs. to 230 lbs. at the farm. Many a good hog is fed out of the select class by keeping him until he is overweight. Some are ruined through early pushing on heavy feed. Others go to market in an unfinished condition, and, while long and smooth, lack the finish which makes profitable killers. The Wiltshire side in greatest demand weighs from 50 to 65 lbs., and comes from the 160 to 210 lb. hog. Around 200 lbs. is the ideal weight at which to market the bacon hog and while hogs may be made up to this weight at five and a half to six months old, from six to six-and-one-half and even up to seven months may be required to make choicest bacon. At the Ontario Agricultural College choice bacon hogs are brought up to 200 lbs. at from six to six and one-half months. Hogs finished too young lack length and muscular development. Those held back until too old are coarse, soft and undesirable killers. Good bacon hogs are long, smooth, trim, neat and muscular, which means strength of constitution but not a round fat belly, and which also means the proper proportion of lean to fat and not a surplus of the latter for the lard kettle. The accompanying illustrations show the right and wrong kinds alive and the desirable and undesirable sides when hung.

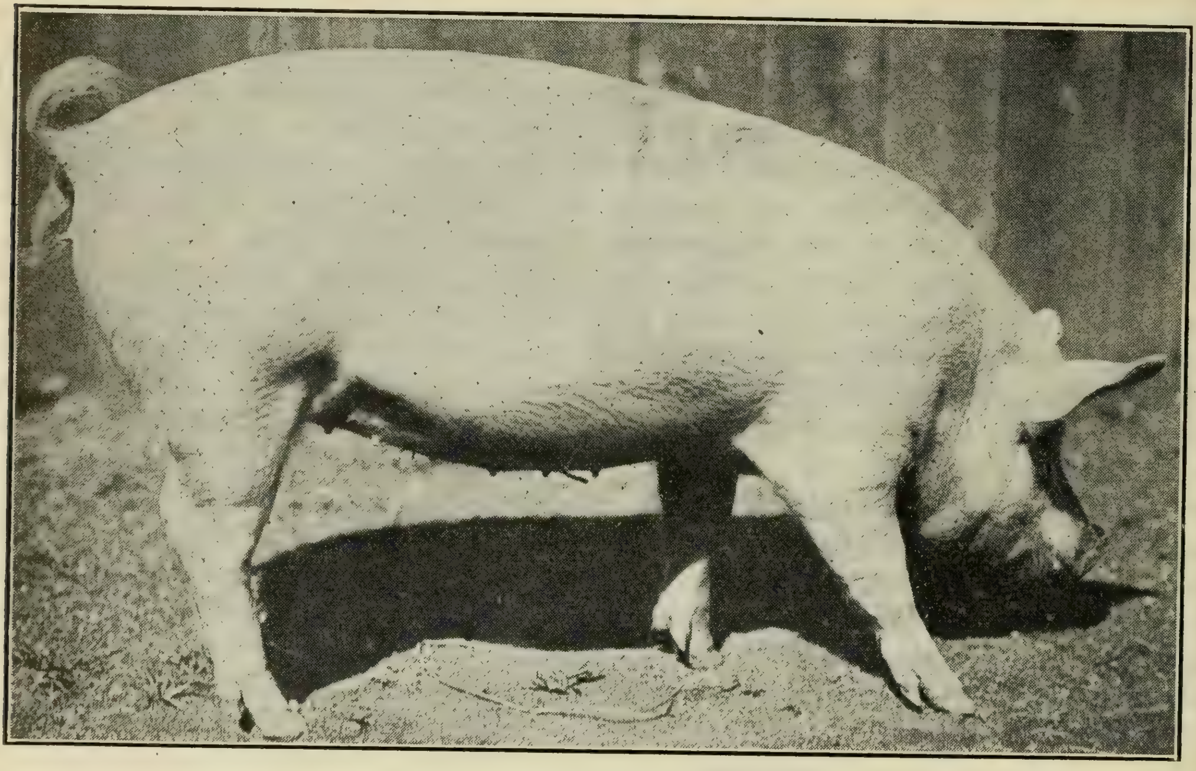


An Undesirable Type.

A thick smooth, side short, jowl and underline heavy, ribs round; a typical fat back, lard type hog.

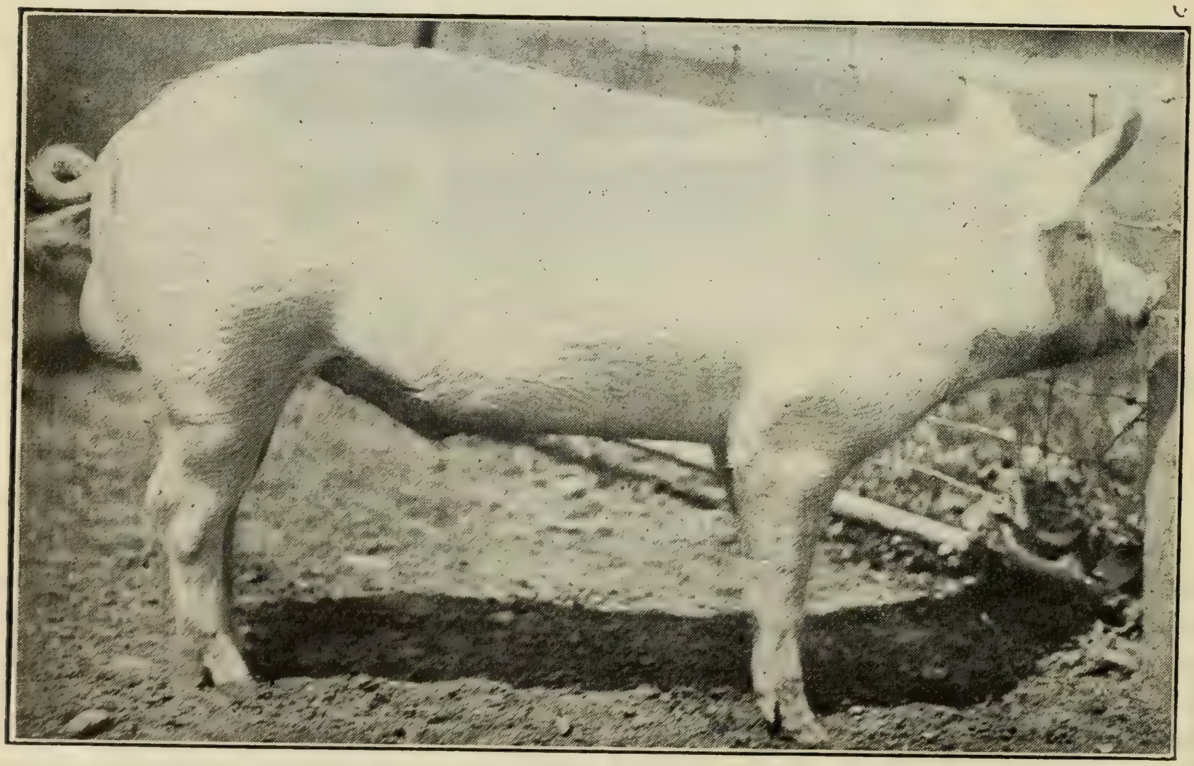
Producing Bacon.

Good bacon hogs may be produced either in summer or winter. Of course, it requires less expensive feed and care in the summer. The strength of the litter depends in no small degree upon the care of the sire and dam. If possible, breed only from a boar of outstanding bacon type himself, and preferably one out of a large even litter with generations of bacon type behind them. The same holds true of the sow. Uneven litters are one of the chief causes of lack of uniformity in product. Thrifty pigs are often held too long, or runts are sold before properly finished. Boars should get little or no service until well grown at eight or nine months old and then only a few sows. Sows, if they are to get the best size and become the best producers, should not be bred until they are eight months old and well grown for their age. Exercise for boar and sow is absolutely essential. The boar should have outdoor exercise in a paddock for from five to ten hours out of each twenty-four hours winter and summer, and the pregnant sow should have the run of a pasture paddock or field in summer



A Good Type of Young Breeding Gilt.

This eight months' old gilt shows the proper proportions to make an ideal brood sow for the production of bacon. Owned by Ontario Agricultural College.



Eight Months' Old Boar.

This young hog is the type from which to produce bacon hogs. He is out of an even litter of 16 pigs. Note length, smoothness, balance and general conformation. Owned by Ontario Agricultural College.

and the barnyard or other paddock in winter. Litters depend upon exercise of the parents. Neither boar nor sow should be kept fat. Thrifty condition means good condition. For the boar, ground oats, wheat middlings and a little barley makes a good ration. With this he should get some mangels or sugar beets in winter and some clover, alfalfa, peas and oats or rape for green feed in summer. Skim milk and whey are always good. In fact, barley and oats mixed makes a good grain ration if it is balanced with skim milk, whey, clover or alfalfa. The following table shows results with winter feeding of the College boars:

WINTER MAINTENANCE OF BOARS.

Boar	Age	Weight	Feed per day	Gains	Cost of feed per day	Cost of feed per 100 lbs. live weight	No. of services
Tamworth.....	10 mos.	285 lbs.	chop, 6.33 lbs. whey, 16 lbs. mangels, 3 lbs.	91 lbs.	11.6 cts.	3.1 cts.	4
Yorkshire......	2 yrs.	446 lbs.	chop, 6.51 lbs. whey, 16 lbs. mangels, 2 lbs.	40 lbs.	11.5 cts.	2.5 cts.	17
Old Yorkshire..	5 yrs.	485 lbs.	chop, 6.51 lbs. whey, 16 lbs. mangels, 3 lbs.	19 lbs.	11.9 cts.	2.4 cts.	10
Berkshire......	2 yrs.	615 lbs.	chop, 6.3 lbs. whey, 16 lbs. mangels, 3 lbs.	14 lbs.	11.5 cts.	1.8 cts.	9

Chop—equal parts barley and oats by weight, $1.40 per cwt.
Whey, 12½ cts. per cwt.
Mangels, 15 cts. per bushel.
Nutritive ratio, 1:7.
Average daily cost, 11.6 cents.

Ground oats should form the basis of the ration for the brood sow. If middlings can be added up to 30 or 50 per cent., so much the better. Barley may be used as a part of the ration, but preferably not more than one-third and never more than one-half. Corn, if used, should not constitute more than one-third the ration, and preferably with one-third oats and one-third shorts or middlings. Sows should summer on alfalfa, red clover, sweet clover, peas and oats or rape with little grain. Skim milk, buttermilk and whey are always valuable for the brood sow.

It is not the object of this leaflet to go into detail on feeding and management of breeding stock. Keep in mind exercise, and feeds intended to produce bone and muscle, not fat.

FEEDING FOR BACON.

Pigs intended for bacon should nurse from six to eight weeks. At the Ontario Agricultural College all litters are left with the sows until they reach eight weeks old. Weaning is done gradually, and there is no better feed than skim milk and middlings with which to start the newly weaned pigs. However, finely ground oats and middlings are often used, and even a mixture of one-third middlings, one-third finely ground oats and one-third barley is often used to good advantage. In the making of bacon it must be remembered that the right type of pig may be ruined by heavy feeding on barley, corn and other heating and fattening feeds just after weaning and before he is properly grown. Rations should be made up with the idea of promoting growth rather than finish. The best growing feeds are: middlings, shorts, finely ground oats, skim milk, buttermilk, whey, tankage (alfalfa, red clover, green), rape and roots. The bacon hog must be grown first, then finished. Heavy feeds too early in life tend to round the rib, shorten the side and lay excess fat on the back and ham as well as make for a flabby jowl and a wasteful middle. Many well bred hogs of good type are spoiled by early pushing with the wrong kinds of feed. Middlings, oats, milk, whey, tankage, and the clovers are high in protein, and so build bone and muscle rather than fat. Exercise helps to build muscle also, and should be freely given to young pigs. Generally speaking, it is well to grow the pigs until they are four-and-one-half to five months old and then finish them as quickly as possible by gradually adding barley in place of middlings, a good finishing ration being composed of two-thirds barley and one-third finely ground oats. If skim milk is not available, tankage up to 8 or 10 per cent. in the ration will prove profitable, particularly in winter feeding. The plan should be to grow the pig before he is finished, and to finish under 230 lbs. at the farm. The all too prevalent idea that pigs make cheaper gains when around 200 lbs. is erroneous. Pigs, like all other animals, make most economical gains when young. It does not pay to hold them over the market weight, either in gains or in market price. Once over the 220 lbs. at the market and they are docked $1 per hundred pounds. All young pigs should get exercise, and, in summer, green feed will reduce the cost of pork production up to nearly 25 per cent. All pigs should have mineral matter. The following has given good results at the O.A.C.: Four bushels charcoal or wood ashes, 8 lbs. salt, 2 quarts of air-slaked lime, 10 lbs. steamed bone meal and 1 lb. sulphur. Place this in a box in a corner of the pen.

CHIEF CAUSES OF PIGS OF THE RIGHT TYPE NOT GRADING "SELECT."

1. *Overweight.*—Overweight at the market. Fed too long, possibly waiting for a rising market. Feeder loses out because they sell for $1 per cwt. less and do not make as economical gains as are made under 200 lbs.

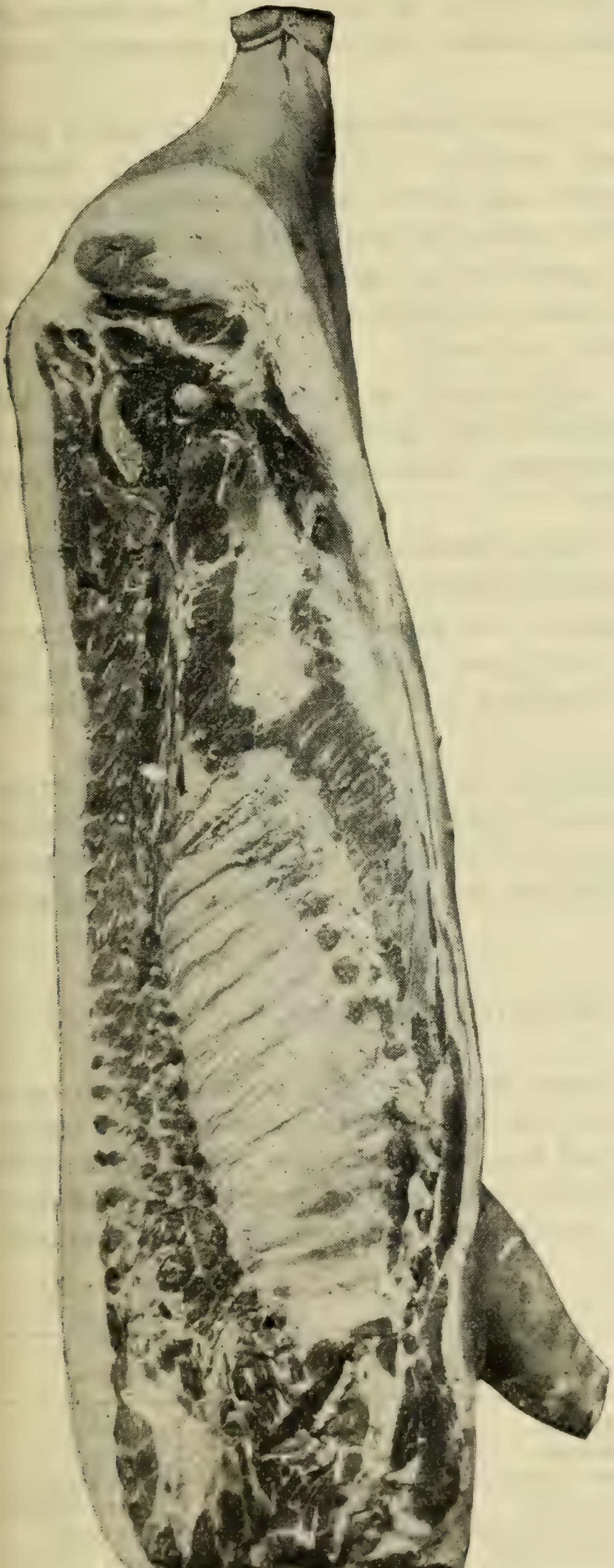
2. *Heavy feeding* just after weaning. Pigs pushed on heavy fattening feeds such as barley, buckwheat and corn too soon after weaning. Pigs must be grown on protein-rich feeds and finished later.

3. *Poor feeding.*—Pigs starved or stunted in early life or held until old, coarse and rough before they are up to market weight. Generally soft in carcase and coarse in texture.

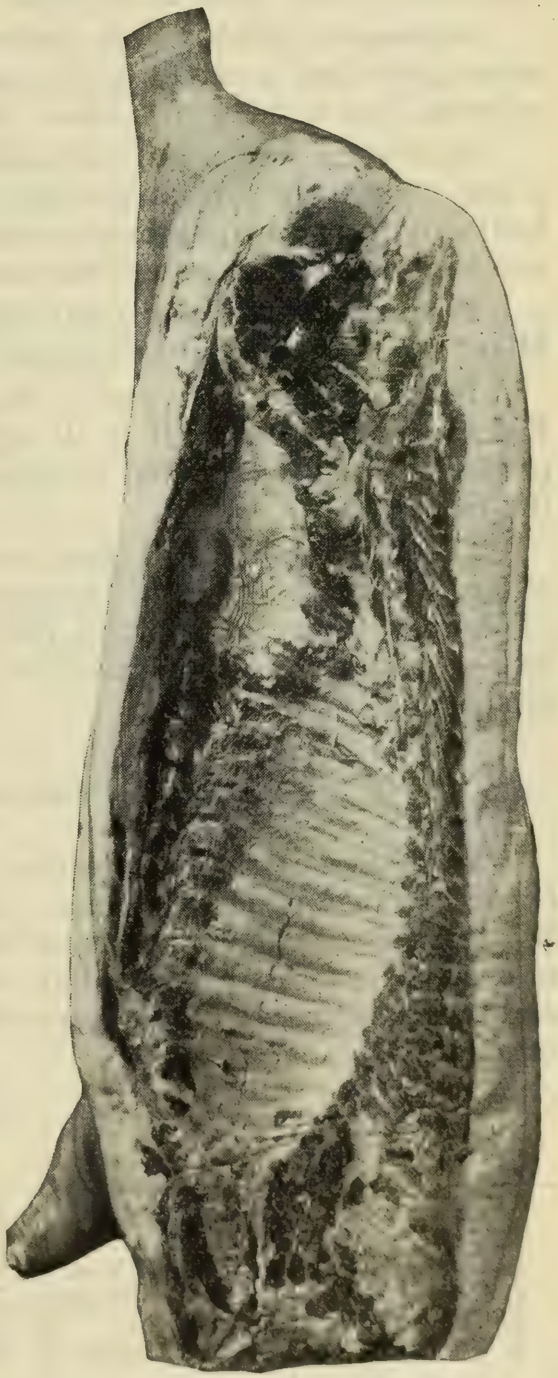
4. *Under finish.*—Pigs not finished to the desired 1¼ inches of fat down the back, generally through lack of feed or a mistaken idea of what the finished bacon hog really is.

SOFTNESS IN BACON.

Softness is one of the chief causes of loss in Canadian bacon. All soft bacon sells at a discount. Pigs fed heavily in early life, particularly on fattening feeds, and at the same time closely confined in pens without exercise produce a soft bacon. Experimental work at the O.A.C. has proven this fact as well as that pigs grown to 100 to 125 lbs. weight on mixed feeds well balanced with skim milk (about 2½ lbs. milk to 1 lb. of meal) or tankage up to 10 per cent.



"Wiltshire" side from a select bacon hog. Note the length, evenness of finish and uniformity.



"Wiltshire" side from hog of lard type. Too short, too fat, and too heavy in front.

in the ration may be finished on corn or barley and still produce a firm, high-quality product. Close confinement in pens from weaning until marketing has a tendency to produce a soft, flabby product. Dairy by-products tend to offset the trouble arising from lack of exercise, but both exercise and skim milk are better than either alone. Unthrifty hogs and all unfinished hogs as well as hogs carried too long on a maintenance ration to keep them from becoming too heavy while holding for a rise in prices generally kill out soft carcases of lower than select grade.

Feeding corn alone for an extended period produces poor gains and a soft, undesirable carcase. Barley and oats produce a firm, satisfactory bacon. Extensive experiments show that roots and green feed, including pasture, clovers and rape, have no injurious effect upon the quality of the bacon.

In summer finishing, for the last month or so, more rapid gains are made where green feed is carted to the pigs inside as compared with allowing the pigs to graze, but it takes just about double the work.

Marketing immature, unfinished pigs should be discouraged. They kill a low percentage carcase and are generally soft and so do not grade select. Unthrifty hogs generally produce soft carcases. Exercise and thrift go together, and thrift and firmness are inseparable.

Feeding on meal and meal alone has a tendency to produce soft bacon. Mixed feeds are safer than exclusive meal rations.

Beans produce soft pork. Buckwheat fed alone has a similar tendency. Fed in a mixed ration, it is all right and gives good gains. Certain oily by-products should not be fed in large quantities but only as a small portion of the ration.

Exercise, rapid growth from weaning up to the finishing age on a mixture of feeds, and a satisfactory degree of finish evenly distributed make for quality of product. Starving, stunting, holding, crowding with heavy feed when young, lack of variety in feed, holding for a higher market all make for a low-grade product.

FEED TO PRODUCE 100 POUNDS OF GAIN.

Many feeders still believe that it costs more to put a pound of gain on a bacon hog than upon a lard hog. This is not correct. The right kind of bacon hog will make gains as cheaply as the lard hog breeds. Some years ago a series of experiments were conducted at the O.A.C. with six different breeds of swine, and the following table shows how they stood in each of five years as to economy of gains:

1st year	2nd year	3rd year	4th year	5th year
1. Berkshire.	1. Berkshire.	1. Yorkshire.	1. Berkshire.	1. Berkshire.
2. Tamworth.	2. Tamworth.	2. Berkshire.	2. Tamworth.	2. Yorkshire.
3. Poland China.	3. Poland China.	3. Duroc Jersey.	3. Yorkshire.	3. Duroc Jersey.
4. Duroc Jersey.	4. Chester White.	4. Tamworth.	4. Chester White.	4. Chester White.
5. Chester White.	5. Yorkshire.	5. Chester White.	5. Duroc Jersey.	5. Tamworth.
6. Yorkshire.	6. Duroc Jersey.	6. Poland China.	6. Poland China.	6. Poland China.

This table shows that the bacon breeds held their own. Moreover, the Yorkshires stood first over the period of five years as to suitability for export bacon, with the Tamworths second and the Berkshires a good third. The other three breeds proved unsuitable for the export trade.

During the past four years a hog-finishing test on outdoor winter feeding has been carried on with results shown in the following table:

RELATIVE ECONOMY OF WINTER GAINS—FED OUTDOORS.

First Year	Second Year	Third Year	Fourth Year
Yorkshire	Berkshire	Yorkshire	Berkshire
Berkshire	Duroc	Duroc	Poland
Duroc	Chester	Chester	Duroc
Tamworth	Tamworth	Berkshire	Tamworth
Poland	Yorkshire	Poland	Yorkshire
	Poland	Tamworth	Chester

NOTE.—These pigs were all fed outdoors with sleeping shelters in place of pens.
They started at an average weight of 100 pounds each and wintered in outdoor runs.
The table shows the relative economy of gains made in six breeds.
There were no Chesters in the experiment in the first year.

All pigs were graded when slaughtered and the grading statement was as follows: Yorkshires, 11 S., 1 T.S.; Berkshires, 6 S., 6 T.S.; Tamworths, 6 S., 6 T.S.; Durocs, 2 S., 10 T.S.; Chesters, 1 S., 8 T.S.; Polands, 0 S., 12 T.S. Note: S = Select. T.S. = Thick smooth.

OUTSIDE VS. INSIDE WINTER FEEDING.

In the Middle Western States large numbers of hogs are fed in winter in open corrals with only improvised shelters. Following out this idea an experiment has been under way at Guelph for four years to show relative economy of gains in six breeds fed outdoors with only open shelters for the hogs. It has been found that the pigs must reach about 100 pounds in weight before they will stand the rigours of an Ontario outdoor run in winter. Young pigs just weaned will not make satisfactory gains outdoors from late November to late March, but where the pigs are farrowed fairly early in the fall and have reached 90 to 110 pounds in weight they seem to do fairly well in these outside lots if they have a dry shelter in which to sleep. The shelters these pigs had were open so that they could go in and out at will. In the winter of 1925-26 a number of these pigs fed outside were compared with a similar number of like pigs fed inside. The following table shows that each lot made a profit over cost of feed, but that those fed inside made just a little higher returns than those fed in the open. However, if cost of housing had been considered, those fed outside would possibly nearly equal those fed in an expensive pen. The following tables show the results in brief:

MEAL REQUIRED FOR 100 POUNDS GAIN.

	Outside Feeding	Inside Feeding
Yorkshires	421.6 lbs.	377 lbs.
Tamworths	395 lbs.	346 lbs.
Berkshires	339.6 lbs.	276 lbs.
Average	385.4 lbs.	333 lbs.

MEAL AND MEAL EQUIVALENT FOR 100 POUNDS GAIN.

	Outside Feeding	Inside Feeding
Yorkshires	569.2 lbs.	532 lbs.
Tamworths	549.2 lbs.	480 lbs.
Berkshires	464.9 lbs.	386 lbs.
Average	527.7 lbs.	466 lbs.

NOTE.—Skim milk was fed with the meal and in this table is brought to meal equivalent.

PROFIT OVER COST OF FEED.

	Outside Feeding	Inside Feeding
Yorkshires, per hog	$6.12	$7.17
Tamworths, per hog	6.68	6.67
Berkshires, per hog	7.96	8.58
Average	$6.92	$7.47

These tables show a very good average profit for the three bacon breeds fed outdoors, but the Yorkshire does not seem to stand the outdoor feeding quite as well as the other two breeds do.

PURE-BREDS VS. CROSS-BREDS IN PORK PRODUCTION.

During the winter of 1925-1926 a feed test was made at the O.A.C. to determine the comparative economy of pork production between pure-bred hogs of the three recognized bacon breeds and the respective crosses of the same breeds. For this purpose the following hogs were used in the trial: One pen each of pure-bred Yorkshires, Berkshires and Tamworths, Tamworth-Yorkshire cross-breds, Yorkshire-Berkshire cross-breds, and Tamworth-Berkshire cross-breds.

In selecting hogs for the experiment an endeavour was made to obtain hogs of fairly uniform size and age and, at the same time, obtain lots of as nearly the same blood lines as possible. To this end the pure-bred Yorkshires and the dam of the Tamworth-Yorkshire crosses were of the same blood lines; in turn the sire of the Tamworth-Yorkshire crosses and that of the Tamworth-Berkshire crosses was the same, the pure-bred Berkshires and the dam of the Yorkshire-Berkshire crosses were of the same blood lines and the dam of the Tamworth-Berkshire crosses carried some of the same blood as the pure-bred Berkshires; the only hogs used in the trial which were of distinctly different breeding were the pure-bred Tamworths which, however, were sired by an outstanding boar.

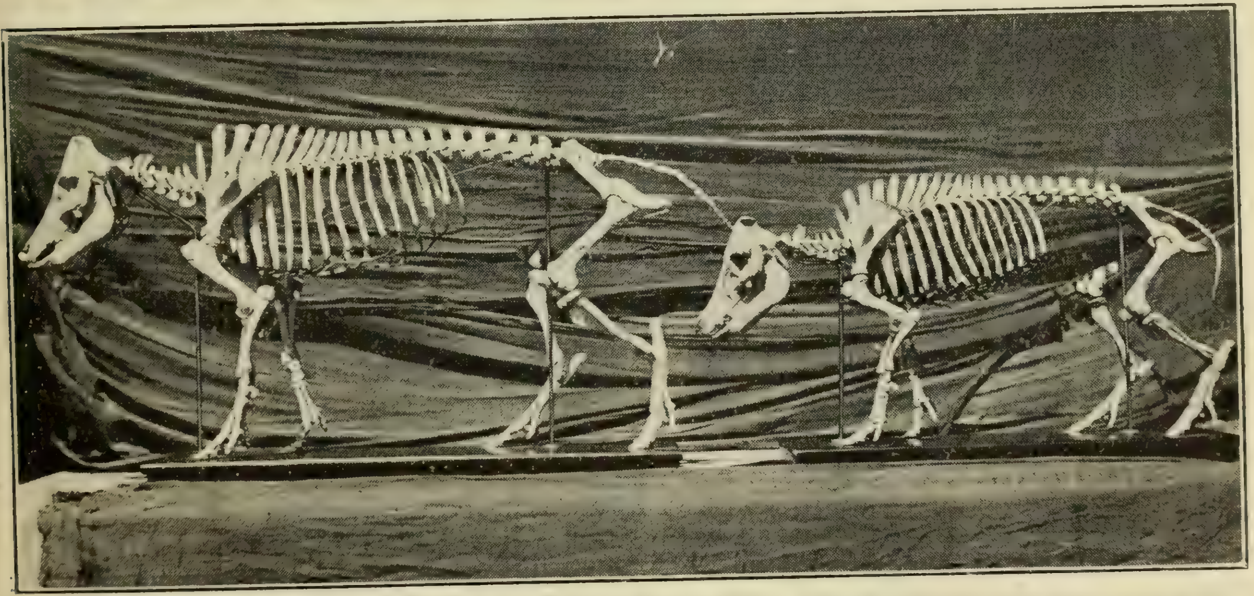
All pens were given the same treatment and were fed the same rations at the different stages of growth and finishing and, as far as possible, marketed at the same weight.

The following is a brief statement of the findings:

	Pure-breds	Cross-breds
No. of lbs. of meal required for 100 lbs. gain	333.3 lbs.	352.3
No. of lbs. of meal or meal equivalent required for 100 lbs. gain	466.0	506.3
Average daily gain per hog	1.66 lbs.	1.23 lbs.
Average profit over feed consumed per hog	$7.14	$4.94

NOTE.—These hogs were fed skim milk and mangels along with the grain and the supplements are expressed in terms of meal equivalent.

So far as grading on foot was concerned, there were the same number of selects in the cross-bred lots as in the pure-bred lots; however, on the rail, while there was only a slight preference for the pure-breds so far as depth and uniformity of depth of fat down the back was concerned, the size and evenness of the belly streak in the carcasses of the pure-breds in this particular test was decidedly superior to that of the cross-breds; moreover, as a lot, the carcasses of the pure-breds were better balanced than those of the cross-breds.



The skeletons of two hogs which weighed 230 lbs. each when alive. The larger frame is that of a bacon hog and the smaller that of lard hog.

THE FRAMEWORK OF THE BACON HOG.

Some leading breeders of bacon hogs have for many years believed that something should be done to show a comparison of the skeletons of a typical select bacon hog and a typical thick-fat lard hog of similar weight. Accordingly the swine breeders' association agreed to furnish the pigs and the College undertook the expense of degreasing and mounting. The champion bacon barrow at the 1923 Royal Agricultural Winter Fair, weighing at time of killing 230 pounds on foot, was selected as an outstanding representative of a bacon hog. He was long, smooth, trim, firm and, as his owner said, "full of lean meat." The other hog was a typical thick-fat or lard hog of the same weight but slightly older. He was short, fine in the bone, heavy in the jowl, round on the rib, bulging in the ham and rather flabby in the underline. Skeletons were prepared and mounted from these two hogs and they furnish an excellent basis for a study of type. The first thing one notices is the differences in height and length between the two. The skeleton of the bacon hog shows more bone of cleaner, flatter, flintier quality than is the case with the lard hog. It stands higher up and shows a leveller rump. There is a great difference in the shape of the bones, even those of the legs showing flatter and more quality in the bacon hog. But in the ribs there is a very marked difference. The ribs of the bacon hog are much flatter and the spring they show from the backbone is not nearly so marked as in the lard hog. They are also set farther apart. The shoulder blades are also set flatter and smoother on the bacon hog. There seems to be a marked relation between amount, quality and shape of bone and muscle or lean meat.

Another point of importance is the fact that the brain cavity and spinal cord capacity is much greater in the bacon hog skeleton than in that from the lard hog. This would seem to indicate that nervous development and lean meat may go together.

Another important point is shown in the two skeletons. The thoracic capacity of the bacon hog was much greater than that of the lard hog, which would lead one to think that he might have had a stronger constitution even though his ribs were not sprung out at right angles from his back bone as in the lard hog. The abdominal capacity was also greater in the bacon hog. This may serve to substantiate the claim that good bacon hogs will make just as cheap and economical gains as will lard hogs.

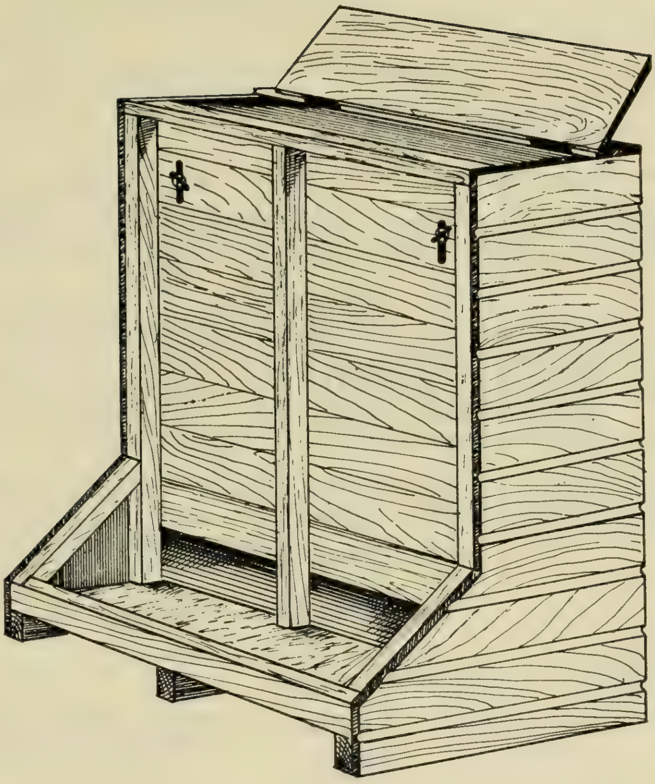
A further interesting fact is noted from the skeletons. That of the bacon hog has fifteen pairs of ribs while that of the lard hog has only fourteen pairs. We have made considerable investigation of this factor and have found that most select bacon hogs have at least fifteen pairs of ribs while most hogs of the so-called thick smooth type have fourteen pairs. A considerable portion of the long hogs have sixteen pairs and we have found one with sixteen ribs on one side and seventeen on the other. One naturally wonders whether there is any connection between the number of ribs and the length of the hog.

The Self-feeder for Hogs.

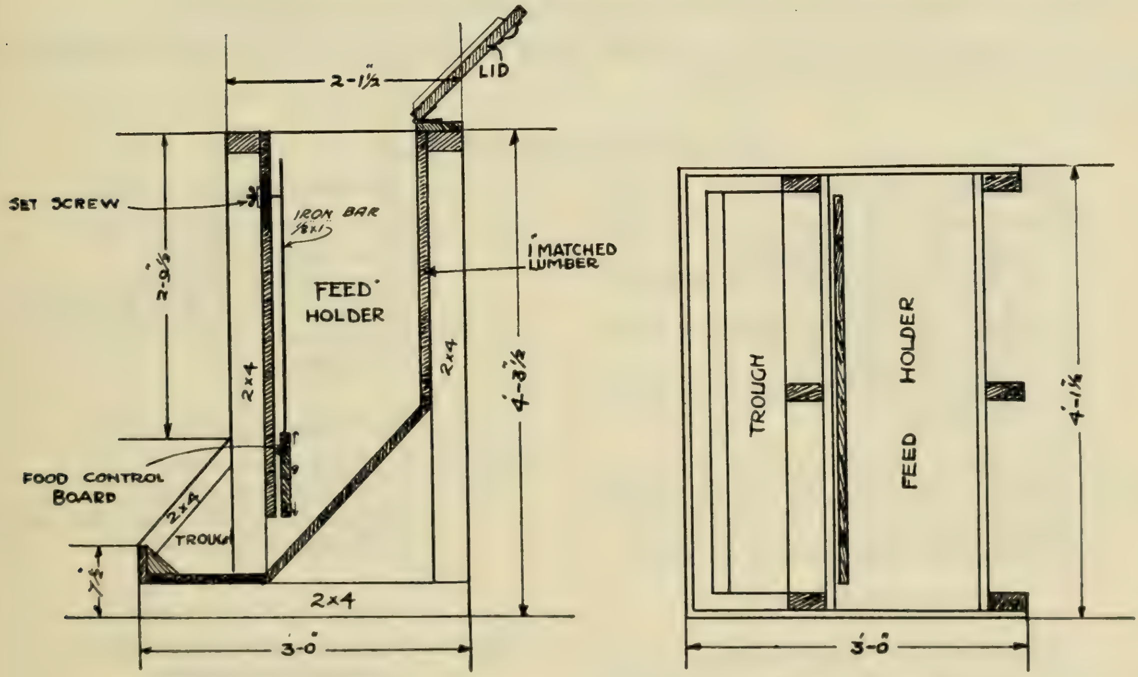
During recent years considerable work has been done with self-feeders for growing and fattening hogs. The self-feeder has advantages in outside runs. It cuts down labour to some extent but it is doubtful whether hogs can be as successfully grown into market selects on the self-feeder as by the best hand feeding. There is a danger of the pigs overdoing their grain ration a little and becoming too fat before properly grown. Satisfactory gains are made on the self-feeder.

For inside feeding the device is of doubtful value. In an experiment at the O.A.C., pen-fed pigs made practically the same gains on the self-feeder as where hand fed on the same meal mixture. The big advantage claimed for the self-feeder is that it saves labour where pigs are grain fed while on pasture, but it is more valuable in the production of lard hogs than in bacon hog feeding.

The following illustration shows a handy type of self-feeder and is self-explanatory.



VIEW



SECTION **PLAN**

SELF-FEEDER FOR HOGS

With good feeding it requires around 400 lbs. of meal or its equivalent to produce 100 lbs. of gain, and the big thing to remember is that there is very little difference in cost of gains with the various breeds, but there is a difference in grade of product which means more money for the kind that grade select.

STANDARD RATIONS FOR BACON HOGS.

Breeding Boars

Equal parts barley and oats (ground).

2½ lbs. whey or skim milk per lb. grain.

2 to 3 lbs. mangels or sugar beets.

For summer—Green alfalfa, red clover or peas and oats may take place of roots and milk.

Tankage may be used up to 8 per cent. in place of skim milk or whey in winter. Or oilcake meal may be used in about the same proportion. If no skim milk or tankage available, use middlings one-third of ration.

Feed the amount they will clean up in 15 minutes.

Breeding Sows (Dry).

Equal parts barley and oats (ground).
1 lb. per 100 lbs. of live weight.

Whey 4 lbs. per 100 lbs. live weight.
Skimmilk, 2 lbs. per 100 lbs. live weight, or
Shorts or middlings, one-third the grain ration.

Roots, 2 lbs. per 100 lbs., live weight.

Cured alfalfa or red clover, all they will eat in winter.

In summer, 2 lbs. of grain mixture per sow per day when on pasture of clover or peas and oats.

Breeding Sows (Nursing).

For a 450 lb. sow:—
Oats and barley (ground) equal parts, 7 lbs.

Middlings	3 lbs.
Skim milk	22 lbs.
Roots	7 lbs.

Ration when pigs are young increasing to 15 lbs. grain as the litter grows older.

Corn or buckwheat might be used as one-quarter the ration in place of barley.

Whey, tankage, or oil cake could take the place of skim milk.

In summer, green clover, alfalfa, peas and oats or rape would largely take the place of skim milk and roots.

RATIONS FOR MARKET HOGS.

Weanling Pigs up to 75 lbs.

No. 1.—Equal parts of finely ground oats and wheat middlings.
2½ lbs. of skim milk or buttermilk to 1 lb. meal.
If skim milk not available, 8 to 10 per cent. tankage.
(About 1 lb. tankage to 9 or 10 lbs. meal.)

Growing Pigs, 100-150 lbs.

No. 1.—Barley and oats (ground), equal parts.
Skim milk, 2½ lbs. to 1 lb. meal.
Or
Tankage, 8 per cent.

Weanling Pigs up to 75 lbs.

No. 2.—3 parts finely ground and sifted oats.
1 part low grade flour.
Skim milk or tankage as in No. 1.

Growing Pigs, 100-150 lbs.

No. 2.—3 parts ground oats.
2 parts ground corn.
Skim milk or tankage as in No. 1.

Growing Pigs, 75-100 lbs.

No. 1.—2 parts finely ground oats.
1 part ground barley.
1 part wheat middlings.
2½ lbs. skim milk to 1 lb. meal.
If skim milk not available, 8 per cent. tankage.

Finishing Pigs, 150-200 lbs.

No. 1.—1 part ground oats.
2 parts ground barley.
Skim milk, 2 lbs. to 1 lb. meal; or
Tankage, 8 per cent.

Growing Pigs, 75-100 lbs.

No. 2.—2 parts finely ground oats.
1 part ground barley.
1 part low grade flour.
Skim milk or tankage as in No. 1.

Finishing Pigs, 150-210 lbs.

No. 2.—2 parts ground oats.
3 parts ground corn.
Skim milk or tankage as in No. 1.

NOTE.—In feeding all market hogs, rather than give actual amounts of feed per 100 pounds live weight, the writer prefers just the amount they clean up well in 15 minutes. Amounts vary with different litters but the 15-minute period is a safe guide.

Where skim milk is not available, tankage is a fair substitute, but should be fed with care. It should be well mixed with the grain and should be fed in very small amount at first, gradually increasing up to 8 or 10 lbs. in 100 lbs. of the meal mixture. Too little may not balance the ration and so would prove unsatisfactory. Oil cake meal may be used in place of tankage. Where green alfalfa or red clover or peas and oats or rape are available, skim milk, tankage or other protein-rich feed is not so essential. Roots in winter may be used to good advantage in the ration of the growing pig. They may be fed in equal weight with the meal. Feeds not mentioned may be worked in, but the materials stressed here should form the basis of the ration.

Skim milk, tankage or oil cake is not absolutely necessary in the ration for the finishing pig but a little may be used to good advantage.

If corn is used in any large amount in the feed, skim milk, tankage, oil cake, green alfalfa or some other protein-rich feed is necessary in abundance.

No attempt has been made to exhaust the available feeds. The foregoing rations will give an idea of the kind of ration required.

BULLETIN 321] [SEPTEMBER, 1926

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

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Lime and Phosphate

The Effect of Lime and Phosphate on the Yield of Fall Wheat and Clover in Ontario

S. Waterman,
Specialist in Soil Research.

N. J. Thomas,
Specialist in Soil Extension.

The Foundation of Successful Agriculture is a Soil Plentifully Supplied with *Lime, Organic Matter* and *Phosphorus*

THIS IS TRUE FERTILITY

INTRODUCTION

Prof. R. Harcourt, Professor of Chemistry, O.A.C.

On some of the soils of the Province it has been difficult to secure a catch of clover. Experimental work has proven that in many instances this difficulty may be overcome by adding lime, either in the form of slaked lime or ground limestone, to the soil. To demonstrate this fact, we planned an experiment to be carried out in three farms in eight different counties, twenty-four experiments in all. The remarkable results secured the first season led us to repeat the work the following year and again the year after. Thus this experiment has been carried out on three farms in each of twenty-four counties.

In the western part of the Province nearly all of the clover is seeded with fall wheat. It was, consequently, necessary to apply the lime for the clover before sowing the wheat. Previous experimental work has also shown us that phosphates can be applied very profitably for fall wheat. We, therefore, decided to combine the two factors in the demonstration.

The commercial firms selling lime and fertilizers in the Province readily agreed to supply the materials free of charge, this Department to pay cost of transportation and to look after the details of the experiment. The firms supplying the acid phosphate were anxious to include a complete fertilizer in the test. This was agreed to on the understanding that they select the fertilizer and state the rate at which it was to be applied. The experiment thus consisted of four plots, a check, lime alone, lime and phosphate, and a complete mixture, each plot to be one-half acre in size. In the first experiment laid down in the fall of 1922, the complete mixture contained two per cent. of nitrogen, eight per cent. of phosphoric acid and two per cent. of potash, or what is commonly called a 2-8-2 fertilizer. In the second series of experiments this was raised to a 2-10-2, and in the third series, to a 2-12-2. We believe one of the good results of this experiment is the bringing on to the market complete mixtures of this type; for it is undoubtedly true that the highest percentage of phosphoric acid improves the fertilizer for the wheat crop.

The tabulated results show the influence of the lime in the yield of clover, and the really wonderful results obtained from the phosphate, not only as seen in the increased yields of wheat, but in the clover crops following the wheat. These experiments and others, with such crops as canning peas, potatoes and turnips, lead us to believe that, provided legumes are grown regularly in the rotation and the land is in a good state of fertility, acid phosphate alone can be used very profitably for most farm crops. The experiments also show that when legumes have not been given a chance to enrich the soil in nitrogen and the land is in a low state of fertility, a complete mixture may give the most economical results.

FACTS YOU SHOULD KNOW

1. Acid phosphate, as it is called, when well made will not make soil acid. Forty years' continuous application has had no effect.
2. All the phosphate is retained in the soil and there is no loss by leaching.
3. Where the soil is slightly to medium acid, acid phosphate will generally overcome harmful action to crops, due to the soil acidity.
4. For *strongly* acid soils acid phosphate will help but should be accompanied by lime.
5. If lime is necessary, any form recommended in Bull. 313, Soil Acidity and Liming, issued by the Department of Chemistry, will prove satisfactory.
6. If the soil is in a very low state of fertility, nitrogen and potash should be applied with the phosphate. The percentage of either need not exceed three or four per cent. and the percentage of phosphoric acid should be as high as possible.
7. Acid phosphate and lime increases the amount of clover in hay and increases the feeding value.
8. The increase in the clover stand increases the amount of nitrogen removed from the air.
9. Acid phosphate hastens the maturity of cereals from two days to a week.
10. The effect of treatment extends over three years for the phosphate and over four for the lime.

SUMMARY OF RESULTS

AVERAGE PERCENTAGE INCREASE IN YIELD OF WHEAT AND FOLLOWING HAY CROP OBTAINED FROM EXPERIMENTS IN EIGHT COUNTIES, SEEDED THE FALL OF 1922

Treatment	Wheat 1923	Hay following wheat		
		1924	1925	1926
Lime	.9	40.4	27.2	17.2
Lime and acid phosphate	54.6	60.8	36.0	28.3
Complete fertilizer	19.3	37.1	....	....

AVERAGE PERCENTAGE INCREASE IN YIELD OBTAINED FROM EXPERIMENTS IN OTHER EIGHT COUNTIES, SEEDED IN THE FALL OF 1923

Treatment	1924	1925	1926
Lime	9.0	40.7	26.3
Lime and acid phosphate	45.2	62.7	54.8
Complete fertilizer	35.4	32.7	31.8

AVERAGE PERCENTAGE IN YIELD OBTAINED FROM EXPERIMENTS IN STILL OTHER EIGHT COUNTIES, SEEDED IN THE FALL OF 1924

No Lime Needed

Treatment	Wheat 1925	Hay 1926
Lime and acid phosphate	28.1	32.5
Complete fertilizer	29.6	14.8

SERIES I.—LIME AND PHOSPHATE EXPERIMENTS

Having noted the increase of crop from the use of acid phosphate in several local experiments, it was decided by the Department of Chemistry, O.A.C., to establish a series of co-operative experiments over Western Ontario to determine whether all the soils would respond in the same way.

Further, since the preliminary soil survey indicated the presence of fairly well defined areas of acid soils, it was thought desirable to include lime in the experiments as well. This was also partly due to the well known benefits which have been noted from the application of lime to acid soils when clover is grown.*

Since it is desirable under some conditions to use a complete fertilizer containing nitrogen and potash, along with phosphoric acid, a third division was added to the experiment, applying a complete fertilizer, analysis 2-8-2,† at customary rate of application.

PLAN OF EXPERIMENT

The experiment, as originally planned, consisted of four plots each one-half acre in area, arranged in the field so as to overcome any soil variation and to make observation convenient. The plots were as follows: (1) Check (no treatment), (2) Lime (crushed limestone, 2 tons per acre); (3) lime and acid phosphate (crushed limestone, 2 tons per acre, acid phosphate 400 lbs. per acre); (4) complete fertilizer (2-8-2, 2-10-2, or 2-12-2, 300 lbs. per acre).

Plot 1	Plot 2	Plot 3	Plot 4
Check	Lime 2 tons per acre	Lime 2 tons per acre Acid Phosphate 400 lbs. per acre	Complete Fertilizer 300 lbs. per acre

Size of plots ½ acre in every case.

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*For detailed information re lime see Bul. 313, Dept. of Chemistry.

†Complete fertilizers used in 1923 were 2-10-2, 2-12-2, in 1924 2-12-2.

The first experiments were laid down in the fall of 1922 in the counties of Halton, Wentworth, Lincoln, Welland, Haldimand, Norfolk, Elgin and Brant. The District Representative arranged for the location with the farmer and the fields were visited by a member of the staff of the Department of Chemistry. The soil was sampled and samples taken to the laboratory for possible investigation. A record was also made as to previous cropping, drainage, etc. In the majority of cases, experiments were placed where the difficulty in obtaining a catch of clover had been experienced, although not in all cases. As a matter of fact the experiments were designed to demonstrate that clover might be successfully grown on these soils and to bring out the effect of phosphates in wheat.

DETAIL OF OPERATION

The measurement of plots, and application of the lime and fertilizer was attended to by the farmer himself, advised by the District Representative. The fertilizer was applied either broadcast by hand or in contact with the seed by use of the fertilizer attachment on the seeder. This of course would influence its effectiveness, but owing to the wide spread area covered it was found impracticable to provide a drill for the purpose. It was possible, however, in many instances to provide line spreaders, by the Department of Chemistry, which were shipped to the points where they were required. This simplified the application of the lime and more uniform results were obtained than if it had been spread in other ways.

In the spring a questionnaire was sent to each experimenter requesting information as to the following points. (1) winter killing; (2) whether ploughed up or not; (3) general appearance. Later on, the fields were visited by a representative of the department and records of rate of growth, maturity, etc., noted.

When the wheat matured the farmer notified the department, and the yields were taken by cutting out representative portions in square rods. This was immediately bagged, shipped to the College, weighed, dried, threshed, and the yield estimated in bushels per acre. It is recognized that this method is subject to criticism as error is unavoidable, but it is manifestly impossible to obtain experimenters who are willing to keep separate and thresh separately several half acre plots. The cost of transportation on a larger bulk of material was also prohibitive.

The hay was seeded in the spring as is usual. The mixtures varied according to the farmers preference and it was thought well to adhere to the local practice instead of supplying each experimenter with a definite quantity of one mixture. As a result some fields were seeded with alfalfa, others with alsike and others with red clover and timothy.

The yields of wheat, harvested in 1923, are given in the following table.

TABLE No. 1

WHEAT YIELDS, 1923

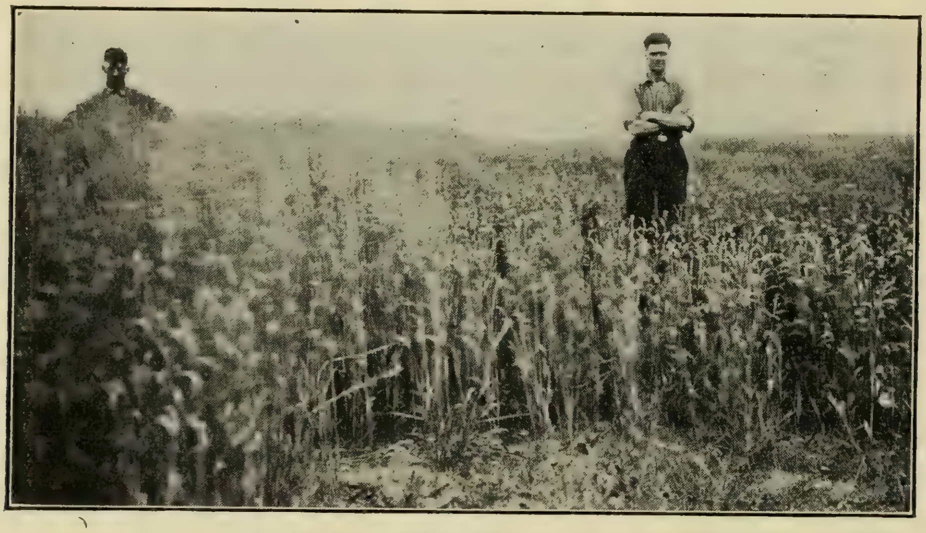
County	Previous Treatment			Check	Lime	Increase	Lime and Acid Phos.	Increase	Complete	Increase
	1920	1921	1922							
Elgin	Oats	Hay	Pasture	18.66	12.3	-6.36	18.0	-.66	18.0	-.66
	Wheat	Barley	S. Clover, (manure, 20 tons)	25.66	25.66	0.0	31.33	5.67	28.66	3.0
Norfolk	Wheat	Corn (man., 12 loads)	Fallow	16.33	16.66	.33	38.66	22.33	21.66	5.33
	Oats	Hay	Wheat	14.66	20.0	5.34	21.66	7.0	17.33	2.66
Brant	....	Oats	Alsike	25.3	18.0	-7.3	31.66	6.3	....	....
Halton	....	Alsike	Barley	23.0	23.0	0.0	40.66	17.66	....	....
	....	Oats (man., 10 tons)	Alsike	23.66	35.0	12.34	50.0	26.34	....	....
Haldimand	....	S. Clover	Fallow (man., 10 tons)	18.0	24.0	6.0	32.0	14.0	29.3	11.3
	....	Oats	Fallow (man., 10 tons)	32.0	28.0	-4.0	38.33	6.43	36.66	4.6
	....	Oats	Fallow (man., 10 tons)	23.3	19.66	-3.7	41.0	17.7	....	....
Welland	Oats	Wheat (man., 10 tons)	Fallow	13.66	15.0	1.34	22.0	8.34	21.0	6.33
	Alfalfa	Alfalfa	Barley	41.6	38.66	-2.94	49.33	8.33	32.66	8.94
	Nearly new la	nd (sod 10 ye	ars)	38.66	38.66	0.0	47.66	9.0	41.0	2.33
	In pasture for	10 years	....	23.0	20.66	-2.34	33.33	10.33	34.33	11.33
Lincoln	....	Wheat, 4-8-4 200 lbs.	Fallow (S.C. plowed in)	24.0	24.0	0.0	34.3	10.33	26.66	2.66
	Oats	Oats	Fallow (man., 13 loads)	17.0	20.0	3.0	47.6	30.6	40.3	23.3
Wentworth	....	Oats	S.C. Pasture	14.3	11.3	-3.0	28.0	13.7	24.3	10.0
	Hay	Oats	Fallow	17.6	30.0	12.4	....	....	....	....
	Corn (man., 10 loads)	M. Grain	Clover	17.3	11.0	-6.3	40.3	23.	29.3	12.0
Average	....	....	....	22.2	22.41	.21 = .946%	34.34	12.14 = 54.68%	26.49	4.29 = 19.32%

All yields expressed as bushels per acre.

DISCUSSION OF 1923 RESULTS

On looking over the results from the treatments applied in 1923, it can be plainly seen that lime has little or no effect on the yield of fall wheat. This is to be expected. Therefore the increase from lime and acid phosphate may be attributed to the acid phosphate alone. This amounted to 54.68 per cent. on the average and in no case did the treated plot give a smaller yield than the untreated.

The complete fertilizer analyzing 2-8-2 was applied at the rate of 300 pounds per acre so cannot be properly compared with the acid phosphate. In the complete mixture 24 pounds of phosphoric acid was applied per acre, while in the acid phosphate 64 pounds was applied. On the other hand the complete mixture supplied six pounds of nitrogen and six pounds of potash, which, however, were unable to overcome the lead established by the larger amount of phosphoric acid supplied by the acid phosphate. The greatest recognized need of Ontario soils is phosphoric acid which explains the effect of the application of the larger amount of this element.



Showing effect of acid phosphate (400 lbs.) on left. Untreated on right. Farm of Lloyd Brooks, Woodstock, 1924.

FINANCIAL RETURNS

Since the lime had little or no effect on wheat yields, it would be unfair to apportion part of its cost to that crop, so considering the cost of fertilizing materials at market prices (August, 1926)—acid phosphate $24 per ton, 2-8-2 at $34.00 per ton and wheat at $1.45 a bushel, the profits from these treatments on the average are as follows:

Increase	Value of Increase	Fertilizer Cost	Profits
	USING ACID PHOSPHATE, 400 LBS.		
12.14 bus.	$17.60	$6.00	$11.60
	USING 2-8-2 FERTILIZER, 300 LBS.		
4.29 bus.	$6.22	5.10	$1.12

From these figures one concludes that complete fertilizer did not give as satisfactory yields nor as good economic returns as acid phosphate.

YIELDS OF CLOVER FOLLOWING 1923 WHEAT

The fields which survived the winter of 1922-23 were seeded in the spring of 1923 and the hay harvested in 1924. The following table gives the yields of hay obtained from these plots.

TABLE No. 2

HAY RESULTS, 1924 FIRST CROP

WHEAT, 1923; HAY, 1924

County	Check	Lime	Increase	Per Cent.	Lime and Acid Phos.	Increase	Per Cent.	Complete Fertilizer	Increase	Per Cent.
Halton	3,088	3,584	496	16	5,516	2,428	78.6	....	....	....
Welland	1,280	2,496	1,216	95	3,072	1,792	140.0	....	....	....
"	2,752	4,064	1,312	46	4,032	1,280	46.5	3,744	992	36
"	2,832	3,808	976	34.6	2,912	80	2.8	3,248	416	10.4
Lincoln	1,984	3,600	1,616	71	3,168	1,184	59.6	....	....	....
"	2,272	4,976	2,704	119	6,464	4,192	184	....	....	....
Haldimand	3,888	4,528	640	16.5	5,008	1,120	28.8	4,704	816	20.9
"	5,336	5,728	392	7.3	7,168	1,832	34.3	....	....	....
Norfolk	4,448	6,912	2,464	55.4	7,136	2,688	60.2	6,432	1,984	44.6
Wentworth	2,960	3,616	656	22.1	5,152	2,192	74	5,024	2,064	69.7
xBrant	....	4,480	....	....	6,272	....	....	....	....	....
Average	3,084	4,331	1,247	40.43	4,962	1,878	60.8	4,630	1,254	37.1

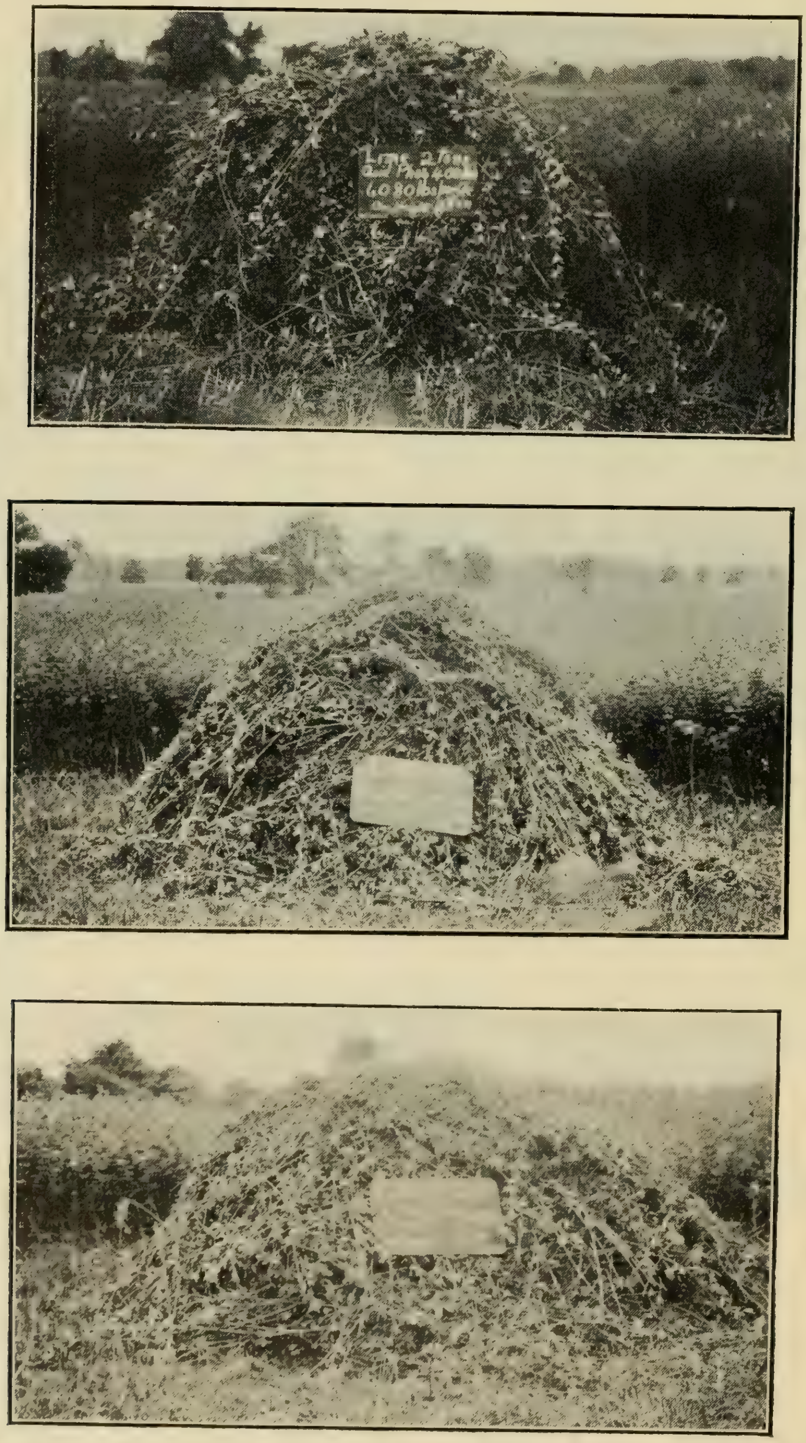
xNot considered in averages.

Increase of 2-8-2 calculated on the checks next which fertilizer yields were taken.

Estimated increase in one field not cut in Haldimand county was acid phos. and lime, 20 per cent. over check.

HAY RESULTS 1925 SECOND YEAR CROP

In 1925 the second year cutting of hay on the fields in wheat 1923 and hay 1924 was made and yields calculated. Of the original twenty-four experiments laid down in 1922 only four survived. In these the effect of the lime alone and lime and acid phosphate were still quite evident. No trace of effect of the 2-8-2 fertilizer could be seen, so that no yields were taken. The following table gives the yields obtained, lime giving an increase of 27.2 per cent. and lime and acid phosphate 36 per cent. This bears out quite clearly the need for and the lasting results from the use of lime and phosphoric acid on Ontario soils.



Showing effect of lime, and lime and acid phosphate on alfalfa the second season. Farm of Eaton Bros., Dunnville.

TABLE No. 3

HAY RESULTS, 1925; SECOND CROP

WHEAT, 1923; HAY, 1924; HAY, 1925

County	Check	Lime	Increase	Increase Per Cent.	Acid Phos. and lime	Increase	Increase Per Cent.	Crop
Haldimand	5,120	5,560	440	8.4	6,080	960	18.7	Alfalfa and R. Clover
Lincoln	2,598	3,328	730	28.6	3,756	1,158	44.5	Alfalfa
Welland	1,856	2,688	832	44.8	2,688	832	44.8	R. Clover & Timothy
Average	3,191	3,858.6	667.3	20.9	4,174	983.3	30.8	

Note 1.—A larger percentage of timothy was noted in untreated plots than on the other two. Lime and Phosphate stimulated clover.
2.—Weights expressed pounds per acre dry hay.

YIELD OF HAY AFTER TWO SUCCESSIVE WHEAT CROPS

WHEAT, 1923-24; HAY, 1925

County	Check	Lime	Increase	Per Cent.	Acid Phos. and Lime	Increase	Per Cent.	Complete Fertilizer	Increase	Per Cent.
Norfolk	2,352	3,098	746	31.7	3,710	1,358	57.8	2,212	-140	-5.9

TABLE No. 5
WHEAT YIELDS, 1924

County	Previous Treatment				Check	Lime	Increase	Lime and Acid Phos.	Increase	Complete	Increase
	1920	1921	1922	1923							
Essex	Corn (man., 10 tons)	Oats	S. Clover	Corn (man., 10 tons)	14.37	20.47	6.10	24.89	10.52	23.05	8.68
	Timothy	Corn	Corn	Oats	17.45	24.88	7.43	35.04	17.59	32.92	15.47
Kent	Wheat (0-16-0 250 lbs.)	Tobacco (man., 20 tons)	Wheat (0-16-0 250 lbs.)	Beans (man., 20 tons)	21.32	24.75	3.43	32.84	11.52	23.60	12.28
	Corn	Oats	Corn (0-16-0 125 lbs.)	Oats	22.78	29.57	6.79	31.02	8.24	28.16	5.38
	Clover	Corn	Wheat (man., 14 tons)	Oats	16.96	27.04	10.08	28.48	11.52	32.07	15.11
Lambton	Oats	Clover	Wheat	S. Clover, hay	28.0	25.72	−2.28	38.7	10.7	44.95	16.95
	Wheat (man., 7 loads)	Oats	Clover	Timothy	27.76	27.33	−0.43	30.5	2.74	29.31	1.55
Middlesex	Clover	Fallow	Wheat (man., 5 tons), 0-16-0 200 lbs.	Clover and Timothy	17.97	19.14	1.17	40.18	22.21	35.17	17.20
	Wheat (man., 15 tons)	Wheat (2-8-2 200 lbs.)	Oats	Clover	26.81	29.71	2.90	35.65	8.84	31.96	5.15
	Oats	Corn (man., 15 tons)	Oats	Clover	34.18	33.97	−.21	42.76	8.58	37.91	3.73
D.B.					22.15	17.66	−4.49	33.65	11.50	31.68	9.53
Oxford	Clover	Pasture (man. 8 loads)	Pasture	Pasture (man. 10 loads)	12.41	13.76	1.35	18.60	6.19	17.38	4.97
Peel	Hay	Corn (man., 12 tons)	Barley	Alsike	20.77	18.52	−2.25	26.29	5.51	27.26	6.49
	Corn (man., 15 tons)	Oats	Oats	S.C. Pasture (man., 12 tons)	23.78	26.66	2.88	34.11	10.33	35.83	12.05
		Alsike	Barley	Fallow (man., 20 tons)	31.20	40.41	9.21	46.86	15.66	42.33	11.13

York	Oats	M. Hay	Oats	S. Clover, hay	33.13	41.76	8.63	45.98	12.85	39.81	6.68
	Oats	Corn (man., 20 tons)	Oats	Potatoes, (man., 20 tons)	32.46	36.36	5.40	44.02	11.56	26.99	–5.47
Northumberland	....	Roots	Oats	Fallow	24.5	xx	.....	32	8.50	29.5	5.0
Average	....	....	....	....	23.78	26.92	2.14 or 9% increase	34.53	10.75 0r 45.2% increase	32.21	8.43 9r 35.2% increase

xAverage of check yields taken. xxNo lime supplied. All yields expressed as bushels per acre.

TABLE No. 6.

WHEAT, 1924; HAY, 1925

County	Check	Lime	Increase	Acid Phos. and Lime	Increase	Complete	Increase
Essex	1,286	2,160	874	3,904	2,618	2,952	1,666
Kent	2,611	2,912	301	3,024	413	2,828	217
Middlesex	1,664	3,024	1,360	3,528	1,864	....	....
Lambton	1,504	2,492	988	....	....	....	....
Oxford	960 2,752	1,920 2,048	860 –704	2,736 3,136	1,776 384	1,632 2,496	672 256
Peel	....	....	....	....	....	....	....
York	4,288 x 6,144	3,520 4,656	–768 –1,488	5,340 5,904	1,052 –240	3,840	–448 ....
Average	2,152	2,582	(1) 130 (2) 876	3,611	1,351	2,749	(1) 590 (2) 703
Percentage Increase	....	....	40.7%	....	62.7%	....	32.7%

xNot taken for average as check plot land was exceptionally good.
(1) Average of seven results; two decreases. (2) Average of five results; all increases. All weights in pounds dry hay per acre.

In 1926 the third year cutting of hay on the above fields was completed. The results obtained continued to show the same marked effects of phosphoric acid and lime. The increase tends to drop as time goes on, but at the same time, the residual effect of the treatment may be clearly seen.

TABLE No. 4

County	Check Yield	Lime	Increase	Lime and Acid Phos.	Increase
xHaldimand...........	3,456	3,968	14.8	4,352	25.9
xHaldimand...........	3,200	4,160	30.	....	....
xLincoln..............	4,800	5,120	6.7	6,272	30.66
Average..............	3,818	4,416	17.2	5,312	28.3

xAll the fields so marked were in alfalfa.

In this connection it is interesting to note the effect of the treatment after two successive wheat crops had been removed. The catch of clover in the first crop was a failure except on the lime and acid phosphate plot. It was therefore ploughed in the spring, summerfallowed and wheat seeded again in the fall. The next spring it was again seeded to hay, the hay crop being harvested in 1925. The results are embodied in the previous table, and are very interesting.

SERIES II. EXPERIMENTS

The experiments laid down in 1922 proved so striking that in the fall of 1923 the same plan was followed in eight more counties, Essex, Kent, Lambton, Middlesex, Oxford, Peel, York, Ontario, with one isolated plot in Northumberland. Owing to some misunderstanding the fertilizers and lime shipped to Ontario County did not arrive in time, so that no results were obtained for the county. In all the other cases, except those ploughed up due to winter killing, yields were obtained.

Table No. 5 gives the yields obtained.

The results obtained in 1924 are much similar to those of 1923 with the difference that lime in these counties accounted for a nine per cent. increase in wheat. The acid phosphate gave a smaller increase while the increase due to the complete fertilizer is noticeably greater, coming up from 19 per cent. to 35 per cent. It will be noted in this case that the analysis was changed from 2-8-2 to 2-10-2 in some cases and 2-12-2 in others, so that the phosphoric acid content was raised considerably, making it more comparable with acid phosphate. The increase in yield is probably partly due to this factor.

RESULTS OF HAY FOLLOWING 1924 WHEAT HARVESTED IN 1925

The hay following the 1924 crop of wheat was harvested in 1925, and the weights are given in the following table. The winter of 1924-25 proved very hard on clover so that out of the original nineteen wheat plots harvested only nine survived to be cut for hay. In three of these lime gave a decrease, as lime and acid phosphate did in one case. This, however, was due to soil variation and is not calculated in on the averages.

TABLE No. 7

HAY RESULTS, 1926; SECOND CROP WHEAT, 1924; HAY, 1925; HAY, 1926

County	Check	Lime	Increase	Increase per cent.	Lime and Acid Phos.	Increase	Increase per cent.	Complete	Increase	Increase per cent.
*Middlesex	1,568	2,184	616	39.3	2,240	672	42.8	1,780	212	13.5
*Kent	3,052	3,725	673	22.	5,360	2,308	75.6	4,561	1,509	49.4
†Lambton	3,300	4,225	925	28.03	.....	....	....	.....	....	....
Average	2,640	3,378	738	27.57	3,800	1,490	64.5	3,170	860	37.2

* Mixed hay, timothy and red clover.
† Alfalfa.

TABLE No. 8

WHEAT YIELDS, 1925

County	Previous Treatment				Check	Acid Phos.	Increase	Complete	Increase
	1921	1922	1923	1924					
Waterloo.........	S. C. Hay	Oats	Corn (manure, 10 loads)	Mixed Hay	28.61	49.16	20.55	46.37	17.76
	Red Clover	Oats	Oats	Sweet Clover ploughed under and 10 loads manure, per acre	52.96	62.67	9.71	60.57	7.61
	Clover	Corn (manure, 12 loads)	Oats	Clover	38.70	45.16	6.46	45.03	6.33
Wellington.......	Mixed Hay	Timothy	Timothy	Timothy	25.83	40.34	14.51	40.18	14.35
Huron............	Wheat manure, 8 tons 0-16-0 at 200 lbs.	S. C. Pasture	Oats	Beans manure, 8 tons 0-16-0 200 lbs.	22.79	44.66	21.87	46.09	23.30
	Hay	Wheat 0-16-0 200 lbs.	M. Grain	Clover	42.71	50.15	7.44	47.46	4.75
	Hay	Pasture	Oats 2-8-4 at 200 lbs.	Wheat (manure, 9 loads)	36.21	37.61	1.40	40.53	4.32
Bruce............	Clover	Corn (manure, 11 loads)	Oats	Fallow (manure, 10 loads)	37.08	41.89	4.81	53.36	16.28
	Timothy 3 years	Oats	Oats (manure, 10 loads)	Fallow	50.18	58.95	8.77	51.55	1.37
	Oats	S. C. Hay	Wheat	S. C. Pasture	31.14	39.58	8.44	33.34	2.20
Perth............	Oats	Hay	Pasture	Fallow (manure, 8 loads)	42.22	61.08	18.86	53.87	11.65
	....	Millet	Oats	Fallow	29 78	52.21	22.43	52.27	22.29
Grey.............	Sweet Clover	Wheat (manure, 6 loads)	Clover & Timothy	Timothy	20.38	24.69	4.31	37.49	17.11
	Oats	Clover & Timothy	Oats (manure, 10 loads)	Fallow (manure, 10 loads)	55.69	50.82	—4.87	50.12	-5.57

North Simcoe.....	Fallow (manure, 10 loads)	Wheat	Hay	Pasture	31.12	44.08	12.96	51. 85	20.73
	Hay	Corn (manure, 10 loads)	Oats	Fallow	40.33	47.59	7.26	47.79	7.46
	Hoe crop (manure, 10 loads)	Barley	Oats	Fallow	43.32	50.59	7.27	53.91	10.59
South Simcoe.....	Wheat	S. C. Pasture	Oats	S. C. Pasture	32.17	40.83	8.66	40.81	7.64
	Fallow (manure, 10 loads)	Wheat	M. Grain	Alsike	20.00	35.00	15.00	35	15.00
Peel..............	....	....	Oats	Clover sod (manure, 8 loads)	46.62	55.36	8.64	.....	.....
Average..........	....	....	....	....	36.38	42.62	10.22— *28.09	46.71	10.79— 29.65*
All yields expressed as bushels per acre									

* Per cent. increase.

TABLE No. 9

Yield of Hay, 1926, Following 1925 Wheat Crop

County	Check	Acid Phos.	Increase	Increase per cent.	Complete fertilizer	Increase	Increase per cent.	Crop
Bruce.....................	3,304 3,416	5,516 4,284	2,212 868	66.9 25	4,900 3,388	1,596 —28	48	Alfalfa. Clover and Timothy.
Grey......................	3,168	3,744	576	15.4	3,600	432	14.2	Clover and Timothy.
South Simcoe..............	2,133 4,000	3,508 5,000	1,375 1,000	69.1 25.0	3,068 5,000	935 1,000	39.1 25.0	Alfalfa. Alfalfa.
Waterloo..................	1,652	2,698	1,046	63.3	2,972	1,320	80.8	Alfalfa.
Peel......................	5,640	6,144	504	8.9	.....	.....	....	Alfalfa.
Average...................	3,330.4	4,413.4	1,083	32.52	3,821.3	490	14.77	

A previous table (No. 7) gives the results of hay on the second year cutting from the fields fertilized for the wheat crop of 1924. They show practically the same results as were obtained in Series I.

SERIES III. EXPERIMENTS

In the fall of 1924 it was decided to carry on these experiments in the remaining counties of Western Ontario. Farms were therefore chosen in Waterloo, Wellington, Perth, Huron, Bruce, Grey, North and South Simcoe, and Peel Counties.

Since these counties all lie within the "high lime" area of the province as shown by the preliminary soil survey* lime was not supplied and the experiment narrowed itself to a comparison of acid phosphate and complete fertilizer. The fertilizer supplied analyzed 2-12-2 and was applied at the rate of 300 pounds per acre compared with 400 pounds of acid phosphate.

Showing effect of lime on sweet clover. Left lime. Right untreated. Welland experimental field. 1926.

In these experiments the complete fertilizer gave a slightly higher result than the acid phosphate but of course the financial returns will not be as great because of the higher cost of the mixed goods. In other words one may apply 400 pounds of acid phosphate at less cost than 300 pounds of complete fertilizer and obtain almost the same yield.

The increase due to fertilization was not so apparent as in 1923 and 1924. The yield of wheat all over the province was higher than usual, the average of the untreated areas under experiment being 36.38 bushels per acre. This was as high as the highest yield obtained by fertilization in 1923. Even at that there was sufficient increase on the average, to pay for the cost of acid phosphate, though not for the complete fertilizer and still obtain a profit from the wheat alone.

HAY RESULTS 1926 FROM 1925 WHEAT

The following table shows the results obtained on hay following the 1925 wheat crop. Of the original twenty-seven experiments hay yields were taken from seven only. This was due to several factors. In several cases the farmers did not seed down as promised. In one case the plots were not marked so identification was impossible. In several the seeding proved a failure and was ploughed up. The results are as follows.

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* See Bul. 298. Preliminary Soil Survey of Ontario, Dept. of Chemistry.

THE EFFECT OF LIME AND ACID PHOSPHATE LASTS OVER SEVERAL YEARS

It is very interesting to note that the effect of treatment with lime and acid phosphate can be noted in the hay crop several years after application. Results have already been given showing the yields of hay obtained on the second year cutting. This is after a crop of wheat and one crop of hay has been removed. The following table gives the yields of hay obtained from alfalfa on the third year cutting, following the wheat crop.

County	Check Yield	Lime	Increase	Lime and Acid Phos.	Increase
			%		%
Haldimand............	3,456	3,968	14.81	4,352	25.92
"	3,200	4,160	30.0	....	....
Lincoln................	4,800	5,120	6.7	6,272	30.66

These plots were laid down in 1922, fall wheat cut in 1923, hay, 1924, hay 1925 and hay 1926. This evidence goes to show that the effect of lime and acid phosphate either singly or in combination will persist over several years, with paying results.

Showing residual effect of fertilizer on clover five years after application. 1,000 lbs. 4–8–4 applied on tobacco. Farm of J. Wilson, R.R. No. 4, Simcoe.

LIME AND ACID PHOSPHATE STIMULATE CLOVERS

It is a well known fact that both lime and acid phosphate stimulate the growth of clovers so that where used a higher percentage of clover is present in the hay. The hay has as a result, greater feeding value from a greater percentage of protein present. At the same time since the total quantity of leguminous plants in the hay is increased and further the ash content of these legumes is also increased, the mineral matter in the hay is much greater than in the untreated areas.

The following illustration shows the effect of acid phosphate and lime used in Welland county (Soil Haldimand Clay*.)

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* See Bul. 298, Preliminary Soil Survey, Dept. of Chemistry, O.A.C.

RATES OF APPLICATION

After the experiments described had been carried on three years it was decided to round them out with a further trial to ascertain whether or not a smaller application of acid phosphate would produce as good results as 400 pounds per acre.

Four experiments were laid down, two in Welland county on Haldimand clay, and the others in Norfolk county on Dunkirk V.F. sandy loam.

The question arose also as to whether the gypsum contained in the acid phosphate had any effect or not. Was the beneficial effect of the acid phosphate due to the phosphoric acid or the gypsum and in what proportion? A further point in the application of lime and acid phosphate together was whether or not the acid phosphate would have given as beneficial results alone without lime.

Showing effect of acid phosphate on amount of timothy in hay. Left, acid phosphate—almost all clover. Right, none—note large percentage of timothy.

To look into these various question this experiment was designed. It consisted of eight plots as follows:

Plot No.	Treatment
1	Check.
2	Acid Phosphate, 100 lbs. per acre.
3	“ “ 200 “ “ “
4	“ “ 300 “ “ “
5	“ “ 400 “ “ “
6	“ “ 500 “ “ “
7	“ “ 600 “ “ “
8	Gypsum equivalent to that contained in 400 lbs. Acid Phosphate.

Half of each plot was limed with crushed limestone at the rate of 2 tons per acre. Each plot is 1/10 of an acre in area.

RESULTS OF RATE OF APPLICATION

The experiment in Norfolk county proved a failure due to uneven stand owing to winter killing by ice. The plots in Welland county were harvested but as we wish to secure results from more than one season, the experiments are being repeated. Taking into consideration all factors an application of from 250 to 350 pounds of acid phosphate per acre would probably be most satisfactory.

FERTILIZERS AND THE HESSIAN FLY

One of the best ways of avoiding damage to the wheat by Hessian fly is to delay seeding till after the date when the fly has laid its eggs on any available wheat crop. Some farmers seed an acre of wheat early—the last week in August—so that the fly deposits its eggs on that acre which is later ploughed up. The main wheat crop seeded normally about September 10th is therefore not affected. If seeding is delayed, except in the southern portions of the province to about September 15, nearly all danger from attacks of the fly will be over. In order that sufficient growth may be made before the cold weather sets in there must be a plentiful supply of available plant food in the soil. Under these conditions fertilizers would supply the necessary plant food, *particularly phosphoric acid*, because this element seems to be the one which influences most the winter resisting qualities of the plant.

ACID PHOSPHATE OR COMPLETE FERTILIZER, WHICH?

The original object of these experiments was to demonstrate the value of phosphoric acid on clover. Comparatively little benefit could be expected from six pounds of nitrogen and six pounds of potash provided by a 300 pound application of a 2-12-2 mixture. If phosphoric acid were the chief need and was responsible, as we believe, for most of the increase, the farmers' hard earned dollars had much better be invested in 16 per cent. acid phosphate which would supply for the same money much more phosphoric acid than the mixed goods.

Pennsylvania reports that on fields yielding 25 bushels or more wheat per acre the addition of neither nitrogen nor potash gave material increases and never enough to pay for the increased cost. Since the average yield of the province in 1923 was 23 bushels per acre and in 1925 about 26, there seems to be a poor argument for the use of a complete mixture on fall wheat.

Some soils, however, are naturally deficient in potash, and some owing to their run-down condition, in nitrogen, so undoubtedly both these elements would pay in such cases to get the crop off to a good start so as to be able to withstand winter injury. But where the soil is in good heart, where clovers have been grown or manure used the only material required is acid phosphate.

If complete mixtures pay, and that can only be determined on each individual farm the mixture should not contain more than three per cent. nitrogen, not less than ten per cent. phosphoric acid and preferably above, and not more than four per cent. potash.

It is the duty of every farmer to make his own farm a small experimental station. First try acid phosphate out. Then include potash and then nitrogen. The Department of Chemistry, O.A.C. will be glad to plan such experiments so that every farmer in the province may find himself, what mixture is best suited to his particular conditions, on his fall wheat crop.

Further advice is always available for the asking, from this Department.

HOW TO TAKE SOIL SAMPLES

Many farmers wish to send soil samples for examination as to lime requirement, organic matter content, etc. The following instructions are therefore added so that these samples may be correctly taken.

Go over your field carefully and decide where you will take samples. Then take a clean spade and cut a hole with a sloping side. Place a sheet of newspaper in the bottom of the hole and cut a slice about one inch thick throwing it over on the paper. Gather the sample and place it in a clean pail or bag. Take all the other samples the same and if there are no great variations in the field mix all the samples together on a table. Then divide the heap in half. Discard one-half and heap the other up. Divide it again discarding half and redivide until a portion of about four pounds is obtained. Mail by parcel post in a suitable box or clean tin container to Department of Chemistry, O.A.C., Guelph.

At the same time send a similar sample of the subsoil from one foot to two feet deep. In many cases the character of the subsoil has a great influence.

At the time of sending the sample answer the following questions and forward in a letter attached to the sample. Pay the postage on both the sample and the letter. *Samples cannot be sent postage free to any provincial institution.*

Questions

1. What is the nature of the subsoil?
2. Is there good natural or artificial drainage?
3. What was the previous cropping (last four years)?
4. What crop do you wish to grow on this soil?
5. When was it manured last? How many loads per acre?
6. Have artificial fertilizers been used? If so, state analysis and quantity per acre?
7. Has lime been applied?
8. Does this land receive wash from higher land?

Write your name and address on the outside of the parcel so we can identify it when it comes in.

Keep in mind that the sample, unless *properly* taken means *waste of time* and possible *incorrect advice* to you, as we at the Department of Chemistry advise you *according to the sample sent in.*

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BULLETIN 322] [NOVEMBER, 1926

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

SOILS AND FERTILIZERS

AND

THE MAINTENANCE OF SOIL FERTILITY

BY THE USE OF MANURES, GREEN MANURES AND FERTILIZERS IN ONTARIO

S. WATERMAN, B.S.A, M.S., SPECIALIST IN SOIL RESEARCH
G. N. RUHNKE, B.S.A., SPECIALIST IN SOIL SURVEYS

INTRODUCTION

PROF. R. HARCOURT, CHIEF OF DEPARTMENT OF CHEMISTRY

There is an increasing demand for information regarding the use of manures and fertilizers in the growing of general farm crops. This is partly due to the introduction of new crops, but more to the desire of the producer to grow larger and better crops. To do this economically it is essential that the grower know his soil, the needs of his crops and the nature of the materials he purchases as fertilizers. Soils vary, not so much in their store of plant food, as in their physical characteristics and the way in which the food may be brought into a form that the plants can use it. Crops differ in their food requirements and in their ability to take that which they need from the soil. Fertilizers carry widely different amounts of plant nutrients and vary widely in the availability of these.

The study of plants, how they grow, how they feed, what they feed on and how they are influenced by the soil and environment, is of vital importance to anyone growing crops.

In this bulletin soils and their characteristics are briefly discussed and the value of an abundance of decaying vegetable matter in them is emphasized. The needs of the plant, the nature of the fertilizing materials available and how these should be used is somewhat fully stated. It is recognized that fertilizer treatment must vary according to the crops grown before and to be grown after their application. It is hoped, however, that the discussion of the fertilizers and their uses may be helpful.

The sections of the bulletin dealing with the fertilizers and their uses, and the value of organic matter has been prepared by Mr. S. Waterman, while Mr. Ruhnke is responsible for that portion dealing with the soils.

THE PLANT

Most young plants start from a seed, which contains an embryo, or germ, that is extremely rich in albuminoids, fat, phosphates, and potash. The seed also contains a store of food, in the form of starch, fat, etc., intended to nourish the young plant until the roots and leaves are sufficiently developed to gather their own supplies. The future health and vigor of the plant will depend on: (1) the amount of food available to the tiny rootlets sent out by the young plant; (2) the temperature of the soil; (3) an abundance of sunshine; and (4) a sufficient supply of oxygen. The plant requires oxygen for respiration, and it gives off carbon dioxide and water from its leaves, that is, it breathes; it assimilates food, and it even excretes waste material. In all this it is very similar to the animal. But it goes further, and from such simple substances as carbon dioxide, and soluble salts found in the soil, builds up the complex sugars, starches, fat and albuminoids which are essential for the life processes of the plant and which form the food of animals. It is subject to improvement by selection and breeding, as is the animal; but, unlike the animal, it is entirely dependent upon the supply of food constituents within its reach, and it has no way of drawing attention to its wants, excepting as its appearance may make them known to the careful and trained observer. A clear conception of the fact that an infant plant, like the infant animal, requires warmth, air, sunshine, and an abundance of easily absorbed food, will greatly aid in understanding the conditions under which it will make the best growth.

Source of Plant-food Constituents

Plants obtain the elements of which they are built partly from the atmosphere and partly from the soil. From the atmosphere it gathers carbon and oxygen, and some plants, through outside agencies, are able to collect nitrogen. Nearly fifty per cent. of the dry matter of a plant is made up of carbon which is entirely derived from the carbon dioxide of the air. Although this compound forms but 3 or 4 parts in 10,000 parts of the atmosphere, the quantity is sufficient, owing to the wind continually bringing fresh supplies to the leaves. For the same reason there is an abundance of oxygen around the leaves of the plant; but, if the soil is not open and porous, there may not be enough in contact with the roots, for it is worthy of note that air in the soil in which crops are growing is as essential to the life of plants as air in the stable is to the animal. This ventilation of the soil is necessary to supply oxygen required in the germinating of seed and to permit the roots to live; for they, too, must breathe, and to supply this life-giving element to the millions of little organisms in the soil which are busy preparing soluble food for the plant. The ventilation of the soil is also required to supply free nitrogen for the use of nitrogen-fixing bacteria, and to remove the excess of carbon dioxide which is being continually set free in the soil.

From the soil the plant derives nitrogen, chiefly in the form of nitrates, the ash substances, and water. Fortunately, although a number of elements are essential for the growth of the plant, there are only four that particularly interest the farmer, as the others are usually found in abundance. These four are, nitrogen, potassium, phosphorus, and calcium. A continuous supply of all the essential elements of plant growth is absolutely necessary; for, if one constituent is absent, or present in an insufficient quantity, no matter what amount of the other nutrients may be available, the plant cannot be fully developed. Consequently, just as a chain is only as strong as its weakest link, so the crop-producing power of a soil is limited by the essential nutrient present in relatively the smallest quantity.

FUNCTION OF PLANT FOOD CONSTITUENTS

Nitrogen. In the absence of nitrogen the plant makes no appreciable growth. With only a limited supply, the plant commences to grow in a normal way, but as soon as the available nitrogen is used up, the lower and smaller leaves begin gradually to die down from the tips and all the plant's energy is centred in one or two leaves. Nitrogen is one of the main constituents of protein, which is possibly the most valuable part of a plant. It is also a constituent of chlorophyll, the green colouring matter of plants; hence with a limited supply of nitrogen, the leaves will have a light green to yellowish colour drying to a light brown yellowish colour. Plants with large, well-developed leaves of a deep green colour are not suffering for nitrogen. An abundance of this substance will produce a luxuriant growth of leaf and stem, but it will retard maturity, and, with cereals, will frequently cause the crop to "lodge." Therefore, when crops such as cereals, tomatoes, potatoes, etc., are to be matured, an over supply of nitrogen is injurious; but with the crops such as lettuce, cabbage, etc., which are harvested in the green condition, an abundance of nitrogen will, other fertilizing constituents being present, tend to produce a strong vigorous growth, and give crispness or quality to these crops.

Potassium, or potash, as it is commonly called, is one of the most important and least variable of all the elements of the ash of plants. It is quite evenly distributed throughout the leaves, stem, and seed, and generally occurs in the entire plant in the largest proportion next to calcium of any of the essential ash constituents. The function of potassium is apparently to aid in the production and transportation of the carbohydrates. This element seems to supplement the action of nitrogen by filling out the framework established by the latter. Potash with nitrogen is always an important fertilizer with special crops where the object is to produce sugar, starch—as with sugar beets and potatoes. It is also apparently essential for the formation of protein, and, thus, indirectly aids in formation of all organic matter.

Potash deficiency—a sickly appearance—roots highly susceptible to rot—the spaces between leaf veins show first characteristic brownish stripes followed later by white spots causing a peculiar crinkling. Fnally the leaves dry up with a more or less brown colour.

Phosphorus, in various forms of combination, is found in all parts of the plant, but tends to accumulate in the upper parts of the stem and leaves, and particularly in the seed. Its function is apparently to aid in the production and transportation of the protein. It also seems to aid the assimilation of the other plant food elements. An insufficient supply of phosphates always results in a poorly developed plant, and particularly in a poor yield of shrunken grain. Nitrogen forces leaf and stem growth, and phosphoric acid hastens maturity.

Phosphorus deficiency is difficult to detect in crops other than cereals. In crops such as sugar beets a lack of this element is indicated by black spots beginning on the edges and spreading over the whole leaf which finally dries up to a dark brown or dark green colour.

Calcium, or lime, is a constituent of the stem rather than the seed, and seems to impart hardiness to the plant. It has been noticed that soils containing an abundance of lime usually produce well nourished crops that are capable of withstanding unfavorable climatic conditions, as drouth and early frosts, better than are crops not so well supplied with lime. The exact function of lime is not clearly understood, but it seems to aid in the construction of the cell walls. According to some authorities, its absence is felt in less time than either potassium or phosphorus. It is claimed that a supply of lime is just as essential to the plant in order that it may form cell walls from sugar and starch, as it is for the formation of bone in animals. It also has a very decided influence on the mechanical condition of the soil, and is a liberator of plant food.

There can be little doubt that a proper balance in the supply of these four important plant nutrients has a very decided influence on the nature of the plant produced. Each has its own particular work to do, and the absence or deficiency of any one of them will cause the death or the incomplete development of the plant. Moreover, they are absorbed during the early stages of growth; for a cereal crop contains at the time of full bloom nearly all the nitrogen and potash which is found in the mature plant; the assimilation of phosphoric acid continues somewhat later. It is thus plain that crops require a good supply of these important constituents of plant growth in a readily available form if they are to make a proper development.

Differences in Habits of Growth

Plants differ very much in their habits of growth and in their ability to secure that which they need. Cereal crops contain much less nitrogen than legumes, but they have more difficulty in securing it. The autumn sown cereals have both deeper roots and longer period of growth than those sown in the spring, and consequently are better able to supply themselves with the necessary ash constituents. The spring tillage for barley, oats, and garden crops aids nitrification in the soil, therefore these crops have less difficulty in securing nitrogen. Barley, however, has a very short period of growth and is shallow rooted and cannot rustle for its food to the same extent as oats. Corn and the root crops are not only spring sown, but have a much longer period of growth than the cereals, and will thus have command of the nitrates produced during the whole summer. They have fairly good root development, but may not always secure all the potash and phosphoric acid required for the production of a full crop.

The striking characteristic of all the legumes is the large amount of nitrogen, potash, and lime found in them. However, although they contain fully twice as much nitrogen as the cereals, because of the bacteria in the nodules on their roots, legumes can make use of the free nitrogen of the atmosphere, and they have comparatively little difficulty in securing the required amount. On the other hand, they have difficulty in collecting potash. Consequently, it may sometimes happen that legumes suffer for want of this constituent on the same soil that cereals would find an abundance. Furthermore they will not do well in an acid soil.

It will thus be seen that plants differ widely in composition, range of root, period of growth, and in their ability to gather that which they need from the soil and air. These are facts which a farmer should be familiar with in order that he may intelligently manure the soil and plan the rotation of crops he wishes to follow in a manner that will give the best possible results.

FARMYARD MANURE

Farmyard manure is one of the most important by-products of the farm. It contains materials which, when incorporated with the soil, serve as food to the plant and it is made up largely of organic matter the importance of which has been discussed in previous paragraph.

The composition of manure will vary with the kind and age of the animals contributing to it, the quality of the feed given the animals, the nature and proportion of the materials used as bedding and the care taken in preserving it.

Influence of Kind of Animal Contributing to it. In the case of a full grown animal neither gaining nor losing in weight, a working horse for instance, the quantity of nitrogen and ash constituents voided in the manure will be nearly the same as that in the food consumed. In cases where the animal is increasing in size, is producing young, or furnishing wool or milk, the amount of nitrogen and ash constituents in the manure will be less than that in the food; that is, it will be in direct proportion to the quantity of these substances which has been converted into animal increase. Thus, with fattening cattle, sheep and with work horses more than 95 per cent. of the nitrogen and ash constituents in the food are voided in the manure. The pig retains a larger proportion of the nitrogen, but no more of the ash constituents. A milking cow retains a still larger proportion of the nitrogen and ash, but the best yield in animal increase is obtained in the case of a young calf, when 70 per cent. of the nitrogen consumed is built into new tissues of the body and only 30 per cent. excreted as manure.

Influence of Quality of Feed. Some feeds are much richer in the plant-food constituents than others. This is well illustrated in the following data which is taken from Warington's Chemistry of the Farm.

		In 1,000 parts of food		
	Dry matter	Nitrogen	Phosphoric acid	Potash
Cotton cake (decorticated)	918	72.0	32.5	15.8
Linseed meal	908	36.1	13.9	10.3
Beans	857	40.7	12.0	12.9
Peas	860	36.0	8.4	10.1
Brewers' grains (dried)	905	33.0	16.1	2.0
Wheat bran	868	22.6	26.9	15.2
Wheat	866	18.7	8.0	5.3
Rye	866	18.3	8.6	5.8
Oats	870	18.1	6.9	4.8
Barley	857	17.0	7.9	4.8
Maize	890	16.6	5.7	3.7
Clover hay (medium)	837	21.8	5.6	18.9
Meadow hay (medium)	863	14.7	4.1	13.2
Bean straw	816	13.0	2.7	18.7
Oat straw	855	6.4	2.8	17.7
Barley straw	858	5.6	2.0	10.6
Wheat straw	864	4.8	2.2	6.3
Potatoes	250	3.4	1.6	5.7
Mangels	120	2.0	0.8	4.8
Carrots	130	2.0	0.9	2.6
Swedes	107	2.2	0.6	2.0

Naturally the excrements derived from cereal grains or clover hay will be richer in plant-food than that from the straws. For the same reason, it is evident that the kinds and amounts of bedding used will cause difference in composition of manure.

Distribution of Plant-food Constituents in Animal Excrements. The farm manure consists of two original components, the solids, or dung, and the urine in about the rate of three to one. The solid excrement generally contains nearly all the phosphoric acid, the greater part of the lime, and some of the nitrogen; while the urine contains the greater part of the potash and usually the greater part of the nitrogen. The distribution of these constituents in the excrement of different animals is well illustrated in the following table.

THE COMPOSITION OF FRESH MANURE

		Percentage of			
		Water	Nitrogen	Phosphoric acid	Potash
Horse:	Solid, 80 per cent	75	.66	.30	.40
	Urine, 20 per cent	90	1.63	Trace	1.25
	Whole manure	78	.84	.25	.55
Cow:	Solid, 70 per cent	85	.48	.20	.10
	Urine, 30 per cent	92	1.21	Trace	1.35
	Whole manure	86	.72	.15	.45
Sheep:	Solid, 67 per cent	60	.90	.50	.45
	Urine, 33 per cent	85	1.63	.05	2.10
	Whole manure	68	1.14	.35	1.00
Swine:	Solid, 60 per cent	80	.66	.50	.40
	Urine, 40 per cent	97	.48	.10	.45
	Whole manure	87	.60	.35	.40

Naturally the above figures require liberal interpretation, as, for various reasons, the excrements may vary widely in composition.

Treatment of Manure. The treatment of manure is very important. As stated above, the greater part of the nitrogen and potash are found in the urine, consequently, if the liquid is lost or the manure is leached with water and the leachings are allowed to drain away, serious loss of nitrogen and potash will occur. Again, the nitrogen in the urine is largely in the form of urea, a compound that is speedily changed by fermentation into ammonium carbonate. This compound is readily broken up with liberation of ammonia, which being volatile, may be lost. This loss of nitrogen occurs while the manure is still in the stable. German experimenters have pointed out that in the case of horses and cows the loss may amount to 30 per cent. of the nitrogen voided by the animal. The best way to diminish this loss is by liberal use of beddings so as to absorb all of the liquid. For this purpose dried peat would be especially valuable. This material is found in large quantities in many parts of the Province and in many cases might be very profitably used as an absorbent in the stable.

Farmyard manure readily undergoes decomposition; the nature of the products formed depend on the amount of air admitted or excluded. If the manure is thrown loosely into a heap it becomes very hot and rapidly wastes. The organic matter in this case is virtually burned, or is "firefanged" as it is commonly termed, and ammonia is one of the products lost. If, on the other hand, the manure is consolidated and kept thoroughly moist so that air is exided, the mass ferments with but little rise in temperature, and some nitrogen s is volatilized. The loss of organic material will be far less with this kind fermentation than in the previous one, but in both cases nitrogen is given from the manure. Experience proves that there is the least waste of manurial nstituents when the manure is preserved in a box stall. Warington quotes experiment which showed that a quantity of food and litter which, in a box ll, yielded 10 tons of manure containing 108 pounds of nitrogen, and when rried daily to a heap yielded only 7.5 tons, containing 64 poiunds of nitrogen.

Undoubtedly, especially on heavy lands, the best returns from the manure n be got when it is put on the land and at once plowed in. The losses that e inevitable when manure is stored would be prevented and a greater amount organic matter added to the soil. Naturally, this is not always possible, t when the manure must be kept it should be made without delay into a solid ap or mass and must not be allowed to become too dry. The practice is metimes followed of drawing manure to the field during the winter months fast as it is made. Provided the land is not too hilly, or too clayey, this ll give good results. It is evident, however, that this method does not prevent sses, but is recommended to economize labour. When the manure is drawn a field and put in a big heap care should be taken to make the heap as firm possible, and, theoretically, it should be covered with earth, but this under ır conditions of labour is impossible.

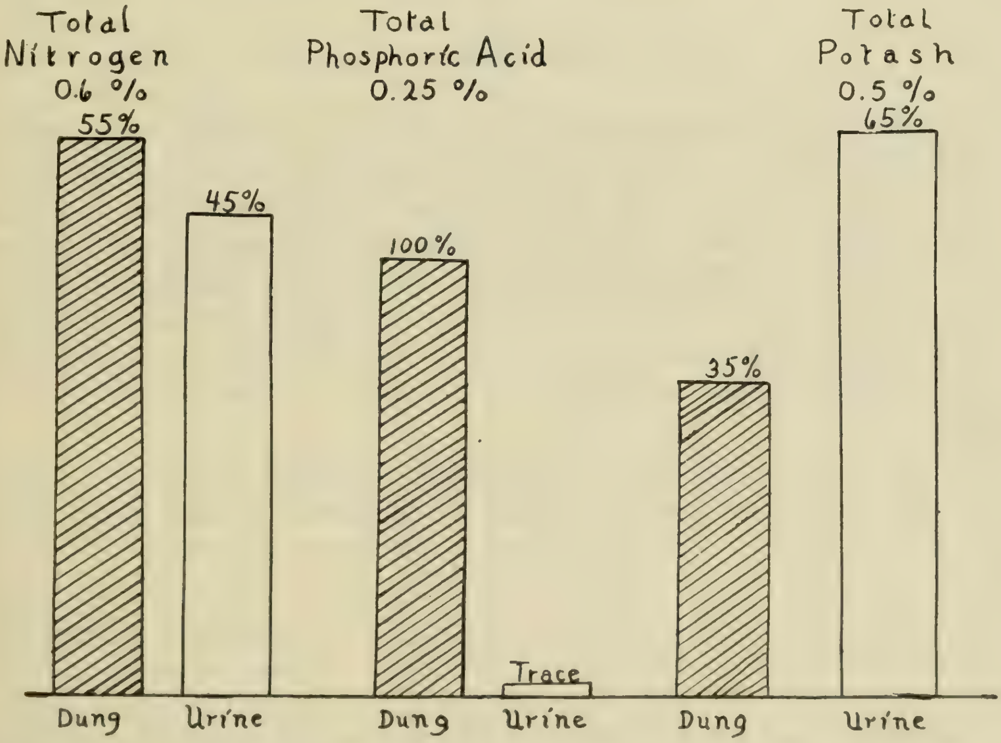

Diagram showing the distribution of nitrogen, phosphoric acid and potash between dung and urine of farm animals.

From what has been said it is evident that there will be heavy losses of lant-food during the storage of manure. Lawes and Gilbert in their early ork on this subject in estimating the manure value of foods supplied to fattening nimals, have first deducted the nitrogen, phosphates and potash which they stimate are retained by the animal, and they then reckoned on having one-half f the remaining nitrogen, phosphates and potash. Even this they thought as too high. Lyon and Buckman in their book on the Nature and Properties f Soils, say "Considering the losses which the food sustains during digestion and the waste of the manure in handling and storage, it cannot be expecte that more than 25 per cent. of the organic matter, 30 per cent. of the nitrogen 50 per cent. of the phosphoric acid, and 30 per cent. of the potash of the origina crop will reach the land in the manure.

It is evident, considering all the factors affecting the composition of manur as it reaches the field that it is impossible to give an accurate statement of th amount of plant-food in stable manure. The nitrogen will vary between .4 and .65 per cent. or even higher if produced by highly fed animals. The amoun of potash may vary from .4 to .8 per cent. and the phosphoric acid from .2 to . per cent. Thus one ton of farmyard manure may contain from 9 to 13 or 1 pounds of nitrogen, 8 to 16 pounds of potash, and 4 to 8 pounds of phosphori acid. An approximate figure readily remembered is that one ton of manur contains 10 pounds of nitrogen, 5 pounds of phosphoric acid and 10 pounds o potash.

Experience shows that no manure can quite take the place of the farmyar manure. It is what may be spoken of as the natural return to the soil of th constituents taken from it. All other substances are in a sense supplements materials added to make good some special deficiency in the soil, or to supply some plant food constituent particularly required by the crop to be grown. Hence, the care and treatment of the farmyard manure is fundamental in all good agriculture.

THE SOIL

In the preceding paragraphs we have seen that the plant derives its sustenance from two main sources, the atmosphere and the soil. The atmosphere supplies the climatic conditions, which are a controlling factor in agriculture, but of course are not within the control of man. The soil, however, is a vital part of the plant environment, for it is not only a limiting factor in crop production, but it is to a large extent, controllable. In so far as it fails to supply the necessary constituents, it limits plant growth. If we can increase the amount of available plant nutrients in the soil, we can affect plant growth accordingly.

One of the prime requisites of successful soil management is a proper conception of the soil. Few people realize its complexity, and many failures to obtain satisfactory yields with fertilizers, arise from neglecting to consider the kind of soil.

All soils have this much in common; they are composed of two classes of materials, mineral matter and organic matter. If you examine a sample of soil closely, you can distinguish between these two materials quite easily. The mineral matter has come from the weathering of rocks and is largely composed of tiny fragments of quartz, feldspar, mica, limestone, shale, etc. It will be as variable in chemical composition as the various rocks from which it is derived. In some localities glaciers have helped to grind up, mix, and transport these rock materials, and the waters resulting from the melting of the glaciers sorted out the different sized particles and aided in their distribution and deposition. The sorting action of the glacial waters has been chiefly responsible for the differences in texture of our soils, i.e., sandy, sandy loam, loam, silt loam, clay loam, clay, etc.

The organic matter is composed of the bodies of plants and animals in varying stages of decay. It is less in amount than the mineral matter in our verage "mineral" soils, being about three to five per cent. In muck or peat ils which are almost wholly organic the amount may be as high as seventy-five eighty per cent.

Not only is the soil a complex medium because of the nature of its con-ituents, but also because these two classes of materials, mineral and organic, e constantly interacting with each other. The soil may be likened unto a very mplicated, sensitive machine, which by reason of its complexity and sensitivity quires the most skillful handling for successful operation.

But just as there are many types of machines there are many types of soils, me of which have been mentioned above. Each presents its own problems management. The sand, the loam, the clay loam and the clay are all distinct their physical properties. Yet we can go farther than merely to distinguish ur soils by differences in texture. What of the influence of the parent rock om which the soil has been derived? A limestone soil we assume to be rich lime; a shale and sandstone soil is very apt to be quite deficient in lime. So oo is a soil derived largely from granite and other crystalline rock material. ome soils have developed under conditions conducive to the accumulation of uch organic matter. These soils will be dark brown to black, and will be ery different to the ashy grey or yellow grey soils which are likely to be almost evoid of this constituent. Some soils have been deposited in deep glacial waters nd are the finest sediments, carried into these waters by streams from the urrounding land. Such soils will be fertile because they will contain an abund-nce of soluble nutrients. These differences mentioned above, and others, orm the basis for a classification of soils. A study of the soils of Southwestern ntario in connection with the Soil Survey,[1] based on such a classification, evealed many striking differences in our soils. These differences are reflected ot only in physical and chemical composition but also in crop adaptation, crop ields and cultural requirements of the soils.

In order to illustrate differences in amounts of plant nutrients contained n some of our soils the analyses of several types appear below.

Type	Nitrogen, lbs. per ac. plough depth	Phosphorus, lbs. per ac. plough depth	Potash, lbs. per ac. plough depth
uck	15,000	1,000	2,500
lack clay	7,200	4,488	48,000
ed clay	1,200	4,000	40,000
ellow gray clay loam	4,460	3,957	40,840
ellow brown sandy loam	3,880	2,542	33,000
ellow sand	2,000	2,093	25,000

While the figures given are for total quantities of plant nutrients, and do ot give any definite clue as to amount of available nutrients, yet they are uitable for relative comparisons.

To use an extreme illustration, consider the nitrogen content of the muck oil as contrasted to the red clay. The analysis shows it to contain ten times s much nitrogen as the red clay soil. It is obvious that a nitrogenous fertilizer ould be apt to give more profitable returns from the red clay soil than from the uck. In the muck soil there is an abundance of nitrogen while the red clay s quite deficient in this element.

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[1] Bulletin 298, Preliminary Soil Survey of Southwestern Ontario, Dept. of Chemistry, O.A.C., Guelph, Ont.

Now contrast the amounts of phosphorus and potash in the same tv soils. The red clay contains four times as much phosphorus and over fifte times as much potash as does the muck soil.

Aside from a consideration of the crop in this case we have two soils wi distinctly different fertilizer requirements. This muck soil essentially nee both phosphorus and potash. The red clay in turn needs nitrogen alone.

Again, compare the analysis of the red clay and black clay for conte of plant nutrients. The black clay has six times as much nitrogen, abou the same amount of phosphorus, and slightly more potash. Here too tl nitrogen requirements of the two soils are distinctly different. Further con parisons between other types will disclose differences quite as marked as tho mentioned above.

It is quite apparent from what has been said concerning the differer soil types that the nature of the soil will have a great influence on its manuri requirements. When we have studied the relationship of the crop and i requirements, to the soil type and its characteristics, then we are in a positio to most efficiently treat the soil for more profitable production.

DRAINAGE

The first essential in soil improvement is to supply adequate drainage fo all soils which are in need of it. A soil that contains more than its optimur amount of moisture is not a warm well aerated soil. It does not provide idea conditions for the plant roots, nor is it a suitable medium for the developmen of the micro-organisms responsible for the decay of organic matter, changin of its nitrogen into an available form and the fixing of nitrogen from the air

These processes which, in a well drained soil, indirectly make the nutrien elements available for plant use, are to a large extent restricted in the undraine soil. Such a soil cannot of course give maximum production. Nor is th response to fertilizer treatment as satisfactory on the undrained soil as it is o the well drained soil. In order that the plant may make the best use of fertilizers the plant environment must be the best possible. To this end proper drainag is absolutely a first essential. If a field is properly drained according to th needs of the soil type, a first great step has been made toward creating th best possible plant environment.

LIME WHERE NECESSARY

Although lime is not a fertilizer it is proper to mention here its place ir connection with the use of commercial fertilizers.

Not all poorly drained soils are sour or acid and in need of lime. Frequently areas of low lying poorly drained soils are richer in lime than the surrounding higher, well-drained soils. In fact these latter are more lacking lime. Their rolling topography and coarse open texture, which account fo their excellent natural drainage, make possible more vigorous leaching anc washing out of their lime, into the lower poorly drained soils.

It is not the intention here to discuss liming and soil acidity. The reade is referred to bulletin No. 313, Liming and Soil Acidity, published by the Department of Chemistry of the O.A.C., for a comprehensive, complete treatment of this subject.

The point to be brought out however, is that on an acid soil fertilizers cannot give as good results as on a neutral soil. An acid soil, like a water-logged soil, is not a healthy environment for most crop plants and even though nutrients are supplied in the form of fertilizers in liberal quantities, the plant's feeding capacity will be limited by its environment. To sum up then, good soil management for most profitable returns from fertilizers, involves first, adequate drainage, and second, where the soil needs it, the application of lime.

ORGANIC MATTER

One of the essential differences between a soil and a mass of rock fragments lies in the organic matter content of the former. Organic matter is necessary in order that the mineral material may become a soil and that it may grow crops successfully. The physical condition of the soil depends largely on the presence of organic matter and the chemical changes are largely brought about by its decay.

The Source of Soil Organic Matter. The source of practically all soil organic matter is plant tissue. Some of this matter accumulates from above the ground, parts of plants that have died and fallen down to become mixed with the surface soil; the remainder is the result of root extension and subsequent decay. Roughly we may divide organic matter into two divisions, (1) the more resistant portion and (2) that part which is well decomposed. The first portion has most to do with the physical condition of the soil while the latter has most to do with the chemical changes taking place in the soil.

The Decomposition of Organic Matter. In nature nothing is wasted. Thus the plant and animal residues in the soil become food for a lower type of life, namely, fungi, yeasts molds and bacteria. These proceed to break down the more or less complex compounds in the organic matter and finally convert the material into a form in which it can be used again by higher plants. Thus we have the higher plants building up their growth by the products discarded by the lower forms of life: then at death they in turn act as food for those lower forms.

During this decomposition all the mineral elements contained in the organic matter are made available to plants. Further the evolution of carbon dioxide (CO_2) with water exerts a solvent action on the minerals of the soil, rendering them available for plant use. This is best illustrated by referring to the lime in the soil which is dissolved in this way and made so that it becomes effective in the soil.

$CO_2 + H_2O — H_2CO_3$
carbon dioxide water gives carbonic acid

$CaCO_3 + H_2CO_3 — CaH_2(CO_3)_2$
limestone (Insoluble) carbonic acid calcium bicarbonate (Soluble)

From the above we see that action of the weak acid dissolving the limestone. This is one of the chief means of loss of lime from the soil; but, is also important because limestone applied to soils is not active unless it is put into solution. Hence we do not expect to see the results from lime applied to soils low in organic matter that we see where it is high.

The Physical Effects of Organic Matter. It is difficult to say which is the more important the physical or chemical effects of organic matter. The latter affects principally the plant food, while the former affects the physical condition of the soil.

The loosening up of clay soils is very important, making the soil more granular, easier to work and improving drainage to some extent. In sandy soils organic matter has a certain amount of cementing action, preventing blowing and drying out. The increased water holding capacity due to organic matter is common to both soils, since the rain fall is held at the surface, or near it. That is where the majority of crops require it. Organic matter also gives to the soil a darker colour. This assists in warming up a soil by absorption of the sun's heat. Since the soil is more open and porous the plant roots have a better opportunity to extend themselves. This means a deeper rooted plant and since a greater area is covered the plant can absorb much more food and hence grow into a strong and healthy specimen.

Nitrogen in Organic Matter. It has been already mentioned that nitrogen is one of the most essential elements. It is also the one of which the loss is greatest. The great function of organic matter is to act as a storehouse for nitrogen, liberating it as required to the growing plant. In order to supply nitrogen, the material ploughed under must contain it. So it is desirable to use as a source of organic matter materials containing a fair amount of nitrogen. Well preserved manure contains about ten pounds per ton, so an application of ten tons per acre would supply all the nitrogen required for almost any crop for a season. Dry clover hay contains about three per cent. nitrogen, so a fair stand of clover turned under would supply considerable of this element. Further the clover would add to the soil the nitrogen which it had secured from the atmosphere. Non legumes such as rye or buckwheat simply return to the soil the nitrogen they removed from it. There is no gain.

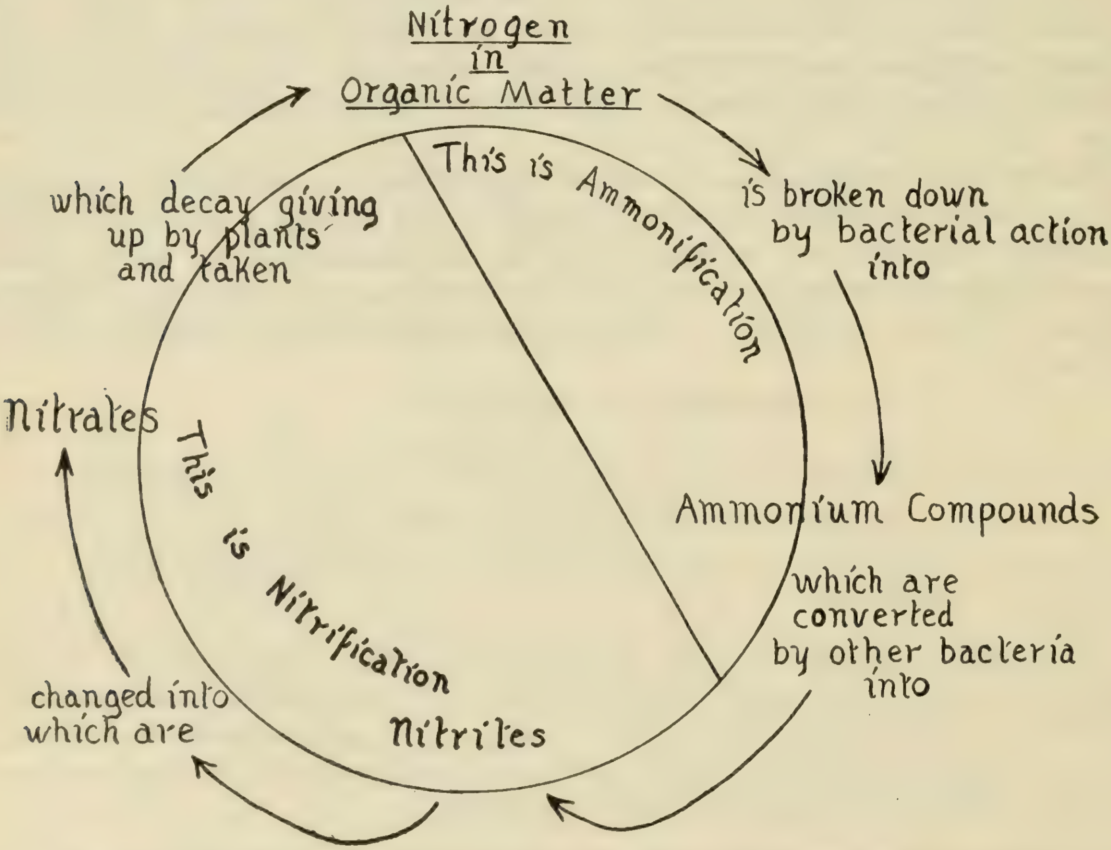


Diagram showing changes in nitrogen during the life and decay of a plant.

Changes of Nitrogen during Decomposition. The effect of organic matter releasing mineral constituents has already been mentioned. The changes which the nitrogen undergoes are also very important. When a soil is analyzed the total nitrogen content might be as high as 6,000 pounds per acre on basis of 2,000,000 pounds soil, plow depth over one acre. Thus there would be enough nitrogen present to grow a sixty bushel crop of wheat for a number of years. If it were all available, (soluble) it would be lost by leaching. But nature releases the nitrogen just fast enough to supply a little more than required for plant growth.

The nitrogen in organic matter is mostly in the form of complex organic compounds which a plant cannot assimilate. When it decomposes these are broken down by bacteria into simpler ones and finally finishes as compounds of ammonia. This breaking down process is termed ammonification. Plants can make use of ammonium compounds to a limited extent if forced to, but it is generally conceded that they prefer their nitrogen in another form.

A further change then is necessary. Other bacteria use the ammonium compounds, and, by a process of oxidation, build them into nitric acid. The nitric acid combines with calcium and other bases forming the nitrates. These are soluble and the plant absorbs them through the roots and uses the nitrogen contained therein. This change from ammonium compounds to nitrates is termed nitrification.

The preceding diagram gives an idea of the changes which the nitrogen undergoes from the time the plant starts to decay till the growing plant absorbs it.

These changes take time and all the nitrogen is not converted into nitrates at once. We rarely find more than fifty pounds of nitrogen as nitrates per acre, although the total nitrogen content may be upward of five thousand pounds. The time required varies of course with the soil, temperature, rainfall and even the crop grown. The presence of lime generally hastens decay, and it is most effective in its action in nitrification. The nitrifying bacteria require the presence of lime in order to function properly. Generally speaking, manure ploughed under in spring will begin to show effect within two months, providing conditions are right. Green manures decay rapidly and the nitrogen becomes available to the crop in a very short time. Such materials as blood meal are very rapid in decomposition, and are converted into nitrates in a very few days. This rule holds good as regards formation of nitrates, *i.e.*, "the higher the nitrogen content of the material the more quickly it will become available to plants."

How Organic Matter May Be Kept Up

It is seen then that the organic matter content of the soil must be kept up in order to retain the crop producing power of the soil. Old organic matter has lost most of its nitrogen and the rate of decay is slow. As a result the amount of carbon dioxide given off is small, and its dissolving effect on the mineral constituents of the soil is almost negligible.

Fresh organic matter gives off a great deal of carbon dioxide and gives up its nitrogen quite readily. So it is desirable to keep adding fresh organic matter to the soil every year. This is quite satisfactorily accomplished by using manure. If the supply is limited it is preferable to spread thinly over a greater area than to apply heavily on a small area. If the manure supply is limited, and it is on all except stock farms, green manuring crops must be used.

In selecting a cover crop suitable for green manures, there are several points that should receive attention. First, the season in which the cover crop is to be grown. A crop selected for October sowing will differ from a crop selected for August sowing. Second, the ability of the crop to collect atmospheric nitrogen. Rye, buckwheat, oats, barley and other non-leguminous crops do not add nitrogen to the soil in the way that clovers and other leguminous crops do. Third, the presence of free lime in the soil. The majority of clovers do not grow well unless lime is present. Rye and other more or less acid resistant plants will grow if the free lime is limited. Fourth, the soil preparation that is necessary for that particular crop: for large seeds such as rye and wheat, less careful preparation is necessary than for smaller seeds such as clover and timothy. Fifth, the time the particular crop will mature or is large enough to plough down. Sixth, the vigour of the plant as regards its growth. If large growth is required, then sow a crop that will give bulk. If large root development is desired, as on soil with a tight subsoil, then select a crop that has this peculiarity. Seventh, the cost of the seed. Some seeds are dearer than others and poor seed is dear at any price.

With these points in mind crops can be selected intelligently, particularly so if the value of a crop from its chemical analysis is considered. The following table will give an idea of the value of an acre of cover crop turned under.

Crop	Nitrogen	Phosphoric acid	Potash
	lbs.	lbs.	lbs.
Clover, new	49.06	11.61	63.55
Clover, second crop	51.47	12.05	36.18
Clover, Sweet	75	48	60
Cow peas	61.9	15.45	77.20
Rye	24.07	11.4	39.0
Soy beans	152.29	27.38	100.89
Timothy	30	10.5	39
Vetch	121.2	27.2	85.5
Spring wheat	20	7	26
Winter wheat	20	7	26

The cover crop chosen should be such that it will not interfere materially with the regular rotation—that is not to displace a cash crop. If there are weeds to be destroyed and a summer fallow is necessary, a crop of soy beans may be sown, at the same time smothering weeds and adding to the fertility of the soil. It is questionable whether bare fallows are worth while, when one considers the loss of plant food.

The effect of a cover crop on the soil moisture is also important. A growing crop removes from the soil large quantities of water and if it is grown *before* the revenue producing crop the latter may suffer from drouth. Further, the cover crop withdraws from the soil solution a great deal of the soluble plant food so that there is not enough left to support the cash crop. It is well known that the replenishing of the supply of available plant food in the soil takes some little time. If two or three weeks elapse between the ploughing down of the cover crop and the seeding of the main crop, the soil has a chance to recover from the draught made upon it by the cover crop. Therefore it is advisable to grow a cover crop *after* the cash crop rather than before, unless it can be turned under several weeks before the main crop is seeded.

Where leguminous cover crops are used, the nitrogen purchased in fertilizers may be reduced. In fact this Department recommends that where clovers are turned under, that no nitrogen be applied in a fertilizer. This is not because it would not have an effect, but because the increased yield will not be in proportion to the increased fertilizer cost. It would be good business, instead of spending the money on nitrogen to increase the application of phosphoric acid and potash.

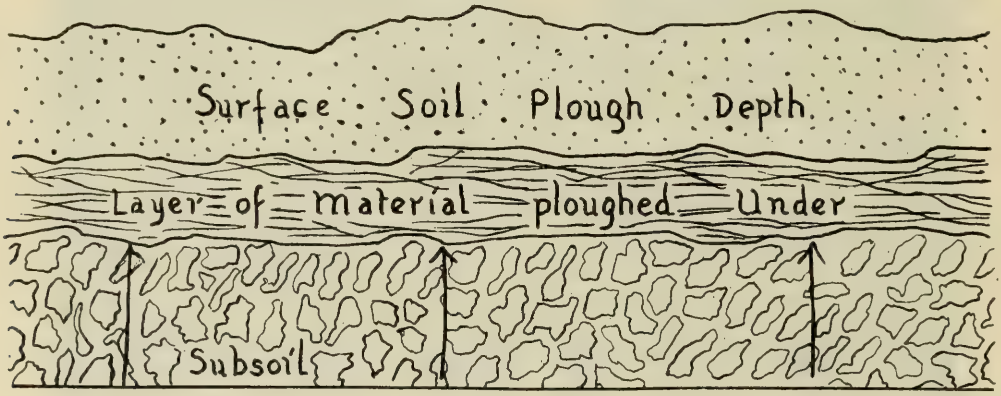
A thorough packing of the soil is necessary after ploughing under green crops to restore capillary action.

Ploughing under rye and vetch for green manure, Norfolk County.

Cover crops, however, sometimes give trouble. If a heavy growth of material is ploughed under the water supply from underneath may be completely cut off and result in drying out of the top plough depth to the detriment of the seeded crop. This can be overcome by rolling or packing after ploughing. Or, if the season has been dry, it would possibly pay not to attempt to crop it that season at all. A case recently came to the attention of the writer where a man ploughed under sweet clover in the spring (May) and planted potatoes in June. The yield was reduced to one-half, largely due to the cutting off of the water supply in a dry season. Had there been good rains there would have been no ill effects.

The proper time to turn down cover crops is when they are in a succulent condition—still growing. Rye is best turned under before heading and this is a safe rule with the others. With soy beans, and other legumes it does not matter so much, because they are naturally soft and decay readily, even when fairly mature. This is not true however, of sweet clover.

In the Western Provinces large quantities of straw are burned annually, and this is true to a certain extent of Ontario. It has been suggested that straw might be added to the soil to supply organic matter. In this connection it is possible that difficulties might arise due to the peculiar action of straw, particularly that of cereals.



Showing how a large quantity of material ploughed under may cut off water supply causing top layers of soil to dry out.

Bacteria need carbon for the production of energy and they secure it from organic matter in the soil. At the same time they need nitrogen to build up their own bodies. Recent investigations have shown that for every hundred pounds of carbon decomposed, about one and one-half pounds of nitrogen are required. If there is this much nitrogen in the straw no ill effects will be noted. But if the nitrogen content is lower than, say three per cent., the growth of the crop seeded on the land will be decreased. This is because the bacteria in order to do their work, cannot secure enough nitrogen from the straw on which they are working and seize the nitrates about them. As a result there is none left for the growing plants. It has been pointed out that growing plants secure their nitrogen as nitrates, so, when the supply is cut off, growth stops. In other words nitrogen starvation sets in. This condition can be remedied by applying with the straw sufficient nitrogen to supply the bacteria with what they require. They will then leave the nitrates alone and the application of straw will not affect the crop unless the water supply is cut off.

The straw of red or alsike clovers, or alfalfa will not have such detrimental effect since they contain a fairly high percentage of nitrogen.

If straw is to be incorporated into the soil it is preferable to stack in the barnyard and allow the stock to run over it in the winter, rather than put in on the land directly from the stack. In this way it becomes partially decayed and the ill effects are not noticed so much. Put on in light applications, say up to five tons per acre, no serious ill results will likely be seen. The best time to turn it under is of course, in early fall so it will be fairly well decayed before the next season.

Artificial Manure

During the world war large production per acre was a necessity and with the shortage of fertilizer material an effort was made to produce artificial manure from the straw of cereals. The original work was done at Rothamsted Experimental Station but has since been repeated at several American stations. The Department of Chemistry at the time of writing has a similar work under way, using a commercial material to produce rapid decomposition. This material is produced by an American firm but its action can be easily duplicated by the use of common materials.

The straw, or plant refuse of any kind is built up in a pile, adding from time to time the other materials required and keeping it damp with a hose having a spray nozzle. When the heap is completed it is thoroughly soaked and let stand for a few days. It is again soaked and sprinkled liberally every two or three days, until it has been wet five times. It is then allowed to stand until ready to use: which should not be more than three months.

This is generally speaking impracticable for farmers but has a possible value for market gardeners or golf clubs who have difficulty obtaining manure. At present the process is not recommended generally but further information will be given to any one applying to the Department of Chemistry, O.A.C. The manure produced is also on exhibit at the Department building.

THE RETENTION OF PLANT FOOD BY ORGANIC MATTER

The presence of organic matter in the soil is important from the standpoint of retention of plant food constituents. These, such as potash, ammonia, etc., are firmly held and will not leach out as much as when the organic matter is low. The retention of soil moisture has already been mentioned.

If cover cropped land is compared with uncropped land kept free from weeds, some interesting facts may be noticed. The following table shows the losses by leaching in both cases. This work was done at Cornell University, New York, and is one of the most dependable results to be found.

AVERAGE ANNUAL LOSS OF NUTRIENTS BY LEACHING. CORNELL LYSIMETER TANKS. AVERAGE TEN YEARS

Condition	Pounds per acre per year			
	N	P_2O_5	K_2O	CaO
Bare	69	....	86.4	557.0
Rotation	7.3	....	68.7	345
Grass	2.5	....	74.0	363.8

The effect of a cover crop, even grass, then, is quite apparent. The increased loss of nitrogen alone on bare fallow for one year if purchased as nitrate of soda at seventy-five dollars a ton, would be worth fifteen dollars. This loss is as nitrates and the cover crop by taking them up as fast as formed prevents this loss. Then when it is turned under that nitrogen becomes available to the revenue producing crop.

SUMMARY OF ORGANIC MATTER

1. Organic matter comes from decaying plant and animal residues.
2. When decomposing it gives up the plant food contained in it to the growing crop and evolves carbon dioxide which brings into solution the mineral portions of the soil.
3. It is of great value for improving the physical condition of the soil.
4. It acts as a storehouse for the soil nitrogen supply

5. The nitrogen contained in it must be changed into nitrates before growing crops can use it. Such change is gradual and sufficient to supply the needs for growing crops.

6. Organic matter may be kept up by manure, crop residues and cover crops ploughed under.

7. The choice of a cover crop is important. It is affected by several conditions.

8. Cover crops are better grown *after* a revenue producing crop than before.

9. Leguminous cover crops are better than non-legumes.

10. Ploughing under a cover crop should be done at least three weeks before seeding the revenue crop. It should be rolled after ploughing and worked.

11. Straw can be used to restore organic matter, but must be carefully handled.

12. Organic matter and cover crops prevent leaching and loss of plant food constituents.

Losses of Plant Nutrients from the Soil

There are two ways in which plant nutrients are removed from the soil, cropping and leaching. In order to fully appreciate the drain on our soils, it is necessary to consider each of these factors separately.

In nature the actual loss of nutrients from the soil is comparatively small, for the plants when they die, fall to the soil and in the process of decay the nutrients they contain are almost wholly returned to the soil. At the same time there is an actual gain of organic matter since this has been built up from the nutrients taken from the atmosphere. The decay of this organic matter is indirectly responsible for the release of mineral nutrients in the soil and the fertility is kept up. In some cases it may even be increased, for losses through leaching are slight and are counter-balanced by the disintegration processes in the soil, and the fixation of nitrogen from the atmosphere.

When the soil is brought under cultivation however, the condition is entirely changed. Crops are removed from the soil and only a portion of the nutrients they contain is ever returned to the soil. Every bushel of wheat made into flour is consumed far from the point of production; every gallon of milk that goes to the city milk route, or to the cheese factory, every animal sold, every crop of vegetables, tobacco, sugar beets, or potatoes removed from the farm, represents a direct loss to the soil.

Of course in dairy farming the great proportion of the crop grown is fed on the farm and hence the greatest possible return of fertility to the soil. Yet the loss in milk or animals sold from the farm remains.

The following table taken in part from Chemistry of the Farm by Warington, shows the amount of nitrogen, phosphoric acid, potash and lime in pounds per acre, removed from the soil by some of the common crops.

Crop	Yield	Nitrogen	Phos. acid	Potash	Lime
Wheat................	30 bus.	50 lb.	21.1 lb.	28.8 lb.	9.2
Barley...............	40 “	48 “	20.7 “	35.7 “	9.2
Oats.................	45 “	52 “	19.4 “	46.1 “	11.4
Corn.................	4 tons	150 “	67 “	106.0 “	30.0
Red Clover...........	2 “	102 “	24.9 “	83.4 “	90.1
Alfalfa..............	5 “	238.0 “	55.0 “	223.0 “	465.0
Potatoes.............	200 bu.	46.0 “	21.5 “	16.5 “	3.4
Sugar beets..........	12 tons	65.0 “	24.0 “	80.0 “	18.0
Tobacco..............	1,200 lbs. leaf	55.5 “	08.0 “	42.0 “	....

The loss of plant nutrients by leaching was first determined at Rothamsted Experimental Station, by analysis of the drainage water collected from tile drains under each of the variously treated plots. The determinations were made from five collections (1866–1868), and the conclusions reached from these analyses are given below.

It was found that the nitrogen leached out of the soil is mainly in the form of nitrates. Phosphoric acid does not appear in the drainage water except in traces. Calcium (lime), appears in the highest concentration, with sulphur next.

The influence of kind of treatment is quite marked on the amounts of lime, nitrogen, potash and sulphur present in the drainage water. The addition of farmyard manure increased the losses of all these nutrients. The application of nitrate of soda increased the amounts of nitrogen, potash and lime leached from the soil. All treatments seemed to increase the amounts of lime in the drainage water, and we may assume that any fertilizer applied to the soil would have the same effect.

More recent investigation over a period of ten years at Cornell Experiment Station, N.Y., provides some very valuable data regarding losses of nutrients through leaching and cropping, and the total loss of the two combined. The soil used in the experiment was a silty clay loam, of the same origin and derivation as a similar soil extensively developed here in Ontario. This factor should make these figures of especial interest to us as the soil conditions so nearly approach our own.

AVERAGE ANNUAL LOSS OF NUTRIENTS BY PERCOLATION AND CROPPING. CORNELL LYSIMETER TANKS. AVERAGE OF 10 YEARS.

Condition	Pounds to the acre per year				
	N	P_2O_5	K_2O	CaO	SO_3
Drainage losses:					
Bare	69.0	....	86.4	557.0	132.0
Rotation	7.3	....	68.7	345.9	108.5
Grass	2.5	....	74.0	363.8	111.0
Crop removal:					
Bare	....	....	....	....	....
Rotation	70.5	43.5	105.4	34.3	41.0
Grass	54.4	28.6	74.0	12.8	29.2
Total loss:					
Bare	69.0	....	86.4	557.0	132.0
Rotation	77.8	43.5	174.1	370.2	149.5
Grass	56.9	28.6	158.0	376.6	140.2

The figures obtained from this work verify the observations made at the Rothamsted Station. Phosphoric acid is not lost by leaching from either a bare or cropped soil. The effect of cropping a soil is to reduce the losses by leaching of nitrates, potash, lime and sulphur. In fact the combined losses due to cropping and leaching on a cropped soil are only slightly greater than the losses by leaching alone from the uncropped bare soil, except in the case of phosphoric acid and potash.

Another point of interest brought out by this work, is the comparative effect of permanent pasture and rotation of crops on conserving nutrients in the soil. From the above table it will be seen that, while the grass land removes less nutrients than the rotation crops, it has almost fully as great conserving effect on the nutrients in the drainage as have the crops in rotation.

The losses due to cropping and leaching may be summarized as follows:—

	Losses of			
Cropping...............	**Nitrogen**	**Phosphoric Acid**	Potash, Lime	Sulphur
Leaching...............	Nitrogen	....	**Potash, Lime**	**Sulphur**

Heavy type indicates in which way the loss of the nutrient is greatest.

With representative figures for removal of nutrients from the soil and the analyses of average Ontario soils we should be able to calculate how long the nutrients in the soil will last under these conditions. Such calculation however does not take into consideration the return of nutrients in the manure and residue from crops nor the addition of nitrogen in the rainfall and by means of nitrogen fixing organisms in the soil.

A discussion of the former sources will include elsewhere, but a consideration of the latter factors is in order here.

From analyses made of the rain and snowfall at the Central Experimental Farm, Ottawa, over a period of seventeen years, Dr. Shutt reports that on the average six pounds of nitrogen are added to each acre of soil annually by rain and snow.

Investigations carried on in the different countries of the world seem to indicate that the amount of nitrogen added to the soil in this way is on the average about the same as that found at Ottawa.

NITROGEN ADDED TO THE SOIL BY MICRO ORGANISMS

There is another way in which a portion of the loss of nitrogen from the soil is made up. Certain small microscopic forms of plants in the soil, known as bacteria and fungi have the power to draw on the nitrogen of the air and utilize it for their growth. Ultimately this nitrogen becomes available to the higher or crop plants and therefore is an important source of the nitrogen supply in the soil.

The amount of nitrogen added to the soil by nitrogen fixation organisms is quite variable, but authorities generally assume that the figure is at least 25 pounds of nitrogen per acre each year and possibly as high as 100 pounds.

Comparing the amount of nitrogen added to the soil in this way with the additions made by the rainfall we can conclude that the soil organisms are about four times as important as a source of nitrogen.

Referring again to the combined loss of nitrogen from the soil by cropping and leaching, which is (77.8 pounds per acre per year) we see that the combined addition of nitrogen to the soil by rainfall and soil organisms (31 pounds per acre per year) offsets nearly 40 per cent. of this loss or in other words equals the addition of approximately 200 pounds of nitrate of soda, per acre per year.

THE NEED FOR MANURE AND FERTILIZERS

Of the plant nutrients lost from the soil nitrogen is the only one which is partly replaced in a natural way. We have seen elsewhere that approximately

40 per cent. of the loss is met by additions of nitrogen in the rain and snow and by organisms in the soil.

The losses of phosphorus, potash and lime on the other hand are complete and there are no natural forces operating to replace these constituents in the soil.

If the normal fertility of the soil is to be kept up additions of materials carrying the necessary nutrients must be made. By returning to the soil the manure made from the crops grown upon it a portion at least of the nutrients will be replaced. The value of such manure as has been previously shown will depend on many factors, and is quite variable.

Frequently the quantity of manure to be obtained is small, especially in specialized farming areas. Therefore it must be supplemented with artificial fertilizers which contain the nutrients in the proper proportions and amounts, to suit the needs of the soil and the crops to be grown.

Under these circumstances it is necessary for us to have a complete knowledge of the nature, composition and uses of farmyard manure and commercial fertilizers so that it may be possible to maintain economically, maximum production with the minimum exhaustion of our soils.

Sources of Fertilizer Materials

Before any discussion of the uses of fertilizers can be dealt with it is necessary to consider the sources of the different plant food elements which are purchased in these materials. The sources are varied and are well worth studying.

Sources of Nitrogen

The sources of nitrogen may be divided into two classes: (1) Natural, and (2) Synthetic. The first are natural deposits such as nitrate of soda and the latter are manufactured products produced from nitrogen obtained from the air. The natural products will be considered first.

Nitrate of Soda, Chile Saltpeter (a natural product).—The commercial article is a fairly pure substance containing about 95 per cent. sodium nitrate. It is obtained from deposits on the west coast of South America, chiefly in Chile. The nitrate occurs as the chief ingredient in the mineral caliche. It is dissolved out of the caliche with water, the solution evaporated and the solids remaining separated. Iodine is recovered during the process, and it has been suggested that since natural nitrate of soda contains small amounts of iodine it is superior to manufactured products.

Nitrate of soda contains about 15.5 per cent. of nitrogen, is water soluble and since it is a nitrate, it is immediately available to plants. In use it must be applied sparingly never more than 250 pounds per acre in one application and never in direct contact with seeds or plant roots.

Dried Blood or Blood Meal (a natural product).—Dried blood is quite extensively used as a fertilizer material. When animals are killed in large slaughter houses the blood is collected and dried. The better qualities are used in various industries such as making buttons and other small articles. The poorer grades are used for fertilizers. The nitrogen very quickly becomes available to crops, i.e., is changed into nitrates and it is an excellent fertilizer.

Blood meal is variable in analysis, but averages about 12 per cent. It has a distinct advantage over the soluble forms of nitrogen carriers in that, not being soluble, it cannot injure the roots unless in excessive applications. It has a particular field in gardening, in planting crops grown in hills where it can be mixed with the soil before planting without any danger of stopping germination.

Bone Meal.—See Bone Meal under Sources of Phosphoric Acid.

Tankage (a natural product).—Organic nitrogenous waste materials such as leather, felt, wool, hair, feathers, etc., are digested in large tanks with steam under pressure, and sulphuric acid added. The product is then dried and ground and is highly available as an organic nitrogenous fertilizer material containing from five to ten per cent. nitrogen, generally about six per cent. It also contains about ten per cent. phosphoric acid so is valuable since it supplies two elements.

The nitrogen in this product is quite available and is safer to use than the more soluble forms of nitrogen compounds.

Fish Scrap—Fish Tankage (a natural product).—Prepared from non-edible fish such as menhaden and dogfish and from offal (heads, tails, entrails, etc.) from fish canneries. The raw fish are cooked with steam and then pressed to remove the oil. The pressed material when ground is ready for market.

This material is rarely sold separately to farmers, but is mainly used in the manufacture of mixed fertilizers. It contains variable percentages of nitrogen from six to ten per cent., generally about eight. This nitrogen is readily available and the material has value as a source of nitrogen over the whole season.

Beside the nitrogen it also contains from 4 to 8 per cent. phosphoric acid which is of value.

Nitrate of Soda (manufactured).—This product is purer generally than the natural form, but is essentially the same. It is prepared by the union of nitric acid with caustic soda, and crystallized out. Generally it contains a slightly higher per cent. of nitrogen than the natural product (about 16.5 per cent.) but is handled in the same manner.

Sulphate of Ammonia; Ammonium Sulphate (manufactured).—This is a salt formed from ammonia and sulphuric acid. The ammonia liquor from gas works and coking plants is treated in a still with lime. This sets free ammonia as a gas which is led into absorbing tanks containing dilute sulphuric acid. Sulphate of ammonia is formed, separated out and dried.

It is also being manufactured extensively in Europe from nitrogen obtained from the air and this form is now competing with the home product. Ammonium sulphate is soluble in water, but must be converted into nitrates by bacteria before the plants can use it. It contained 20 per cent. nitrogen, approximately, and should not be applied in greater quantities than 250 pounds per acre as it may cause root injury. It does not give as rapid results as the nitrates.

Cyanamid (manufactured).—Cyanamid is a trade name for a material containing about 70 per cent. true calcium cyanamide. It is made by passing nitrogen over a heated mass of calcium carbide. The nitrogen present should be considered as organic and hence is not as available as the ammonium compounds and nitrates. It contains about 20–25 per cent. nitrogen which is all available, and proves satisfactory for a season's supply of nitrogen. Experimental work has shown that in some cases it has depressed germination and, f used, should be applied some weeks before seeding. In actual practice, however, little difference is seen.

Ammo Phos (manufactured).—A trade name for a commercial grade of ammonium phosphate made by combining ammonium sulphate with phosphoric acid. This is manufactured in several grades so the analysis is variable, from 10 to 16 per cent. nitrogen and from 20 to 47 per cent. phosphoric acid. In use, attention must be paid to the percentage of plant food present. The nitrogen is quickly available and it is excellent for use as a top dressing.

Calcium Nitrate—Nitrolim, Nitrate of Lime (manufactured).—This is a compound formed from lime and nitric acid. It is produced in considerable quantities by factories from nitric acid made from nitrogen secured from the air. The grade at present on the market contains about 15.5 per cent. of nitrogen and 28 per cent. lime. It is soluble in water and immediately available. In the field it is handled exactly the same as nitrate of soda. There is a great future for this product.

Ammonium Sulphate—Nitrate (Leunasalpeter).—One of the newer synthetic nitrogen fertilizers. It contains a total of about 26 per cent. nitrogen of which one-fourth is in the form of quick acting nitrate and three-fourths in the form of slower acting, but more lasting ammonia. It is made from sulphate of ammonia and ammonium nitrate. This product is of German origin and is for sale in Canada at the present time. Being soluble in water and having a high percentage of nitrogen, it is unsafe to apply in larger quantities than 100 to 150 pounds per acre in one application.

Urea (trade name "Floranid").—This is also one of the newer nitrogenous fertilizer materials. It is produced by combining ammonia and carbonic acid under high pressure and at high temperature. It contains 46 per cent. nitrogen, which is higher than that of any other fertilizer on the market. It is a neutral material which contains nothing but plant food, and which leaves no acid or alkaline residue in the soil. As it is a very concentrated product it must be used carefully and not more than eighty pounds per acre at one application. Its nitrogen is in a form which becomes available very readily and the substance itself is soluble in water.

Potash-Ammonium Nitrate.—This substance supplies both potash and nitrogen to the plant. It also is a new product, one made from nitrogen obtained from the air and in the opinion of this Department is limited in its use in this country. Where both nitrogen and potash are required it might be valuable, but there are few instances of this type since our greatest need in Ontario is phosphoric acid. It contains 15.5 per cent. nitrogen in an available form and 27 per cent. potash, also available.

SOURCES OF PHOSPHORIC ACID

Rock Phosphate-Calcium Phosphate.—This is a natural deposit occurring in many parts of the world. In Tennessee it occurs as a reddish brown rock, while in Florida it occurs as white or grayish white pebbles. It is quarried or dug with steam shovels and crushed. The softer grades are sometimes used directly on the soil, but the most of it is treated with sulphuric acid and sold as acid phosphate. It contains from 18 to 30 per cent. phosphoric acid which, however, is not readily available. It is not used at present in Ontario to any great extent, but is used greatly in some of the states to the south of us.

SUMMARY OF SOURCES OF NITROGEN

Material	Appearance	% N.	When available	Amount equivalent to 100 lbs. Nitrate of soda	Natural or manufactured	Remarks
Nitrate of soda: 1. Natural..... 2. Mfg........	 White crystals... White crystals...	 15.5 15.5	 At once At once	 100 lbs. 100 lbs.	 Natural Mfg.	Used for top dressing. Never more than 250 lbs. per acre at one application. Danger of loss by leaching and of injury by too heavy application.
Blood meal......	Red brown powder.	12	3 weeks	125 lbs.	Natural	No loss by leaching. Splendid for fertilizing hill or row crops in gardens. Safe to use in reasonable quantities. Does not give immediate results.
Tankage........	Red brown powder.	5-10	1-3 weeks	300 of 5% 150 of 10%	Natural	Same as blood meal.
Fish scrap.......	Variable.........	6-10	1-3 weeks	250 of 6% 150 of 10%	Natural	Same as blood meal. Generally used for mixed fertilizers—not often sold separately.
Sulphate of ammonia.	White crystals or yellowish.	20	1-3 weeks	75 lbs.	Mfg.	Used for top dressing or in complete fertilizers. Soluble in water. Must be used carefully. No loss by leaching, but slower in action than nitrates.
Cyanamid.......	Grey to black powder.	20-25	3 weeks or longer	75 lbs. 20% 60 lbs. 25%	Mfg.	Rarely used alone. Used in manufacture of complete fertilizers.
Ammo. phos......	White powder....	10-16	1-3 weeks	150 lbs. 10% 100 lbs. 16%	Mfg.	Good for top dressing. No loss by leaching. Used mainly in vegetable work and on golf greens.
Calcium nitrate..	White crystals...	16.5	At once	100 lbs.	Mfg.	Used the same as nitrate of soda, but also supplies calcium, and is therefore superior. May be lost by leaching.
Ammonia sulphate-nitrate.	White crystals...	26%	At once	57.8	Mfg.	An excellent product used for same purpose as nitrate of soda, but effect lasts longer. Loss by leaching small.
Urea...........	White crystals...	46	1-3 weeks	32.6 lbs.	Mfg.	Can be used for any purpose that nitrate of soda can. Should be used carefully. Is not as rapid in action as the nitrates. Can be mixed with anything but lime. Little loss by leaching. An excellent product.
Potash ammonium nitrate.	White crystals		At once		Mfg.	Little value for Ontario conditions. Possible uses in floriculture.

Basic Slag—Thomas Slag—Thomas Phosphate.—This slag is a by-product produced in the manufacture of steel from phosphatic iron ores or pig iron. The iron, which may contain 2 or 3 per cent. of phosphorus, is run into a converter which is lined with lime and magnesia. Air is blown through the molten iron, oxidizing the phosphorus to the oxide, which combines with the lime in the lining of the converter to form the basic slag. It normally contains about 12 per cent. phosphoric acid and is a fair source of this element. (Its use is becoming less owing to the increasing use of acid phosphate.)

At the present time a great deal of steel is made by the open hearth process and the slag resulting from it does not contain as much available phosphoric acid as that from the Bessemer process. Since, according to the Fertilizer Act, basic slag must contain 12 per cent. phosphoric acid, the open heart product has added to it ordinary rock phosphate sufficient to raise the phosphoric acid content to 12 per cent. or above. As a result the slag, which is fortified with rock phosphate, is not as good as that from the Bessemer process.

Bone Meal—Crushed Bones.—The fertilizer industry got its start from a few men who ground up animal bones and applied them to the soil. To-day the amount of acid phosphate used is far in excess of the amount of bone meal, but ground animal bones are still an important raw material in the fertilizer industry. A large supply of bones comes from abattoirs and butcher shops. These bones are steamed to remove grease and are then ground and sold for fertilizers. Raw crushed bones contain from 3 to 4 per cent. nitrogen and from 18 to 24 per cent. phosphoric acid. The availability of the phosphoric acid is dependent on the fineness of grinding.

Steamed Bone Meal.—When the grease and other organic matter is removed from bones by steaming, the residue is chalky in appearance and easily crushed. Steamed bone meal carries less nitrogen than the crushed bones, only 1 to 2 per cent., and the phosphoric acid content is slightly greater. As a source of phosphoric acid the steamed form is preferable.

Bone Ash.—When bones are burned with the free access of air they burn to a grayish white ash. This ash contains practically no nitrogen but is high in phosphoric acid, containing from 35 to 38 per cent. Bone ash is not extensively produced or used in the fertilizer business.

Bone Black.—When bones are heated in closed retorts similar to those for making coke from coal, the residual charcoal is known as bone black. By this treatment a large part of the volatile organic matter is driven off. This consists of ammonia, and a gas similar to illuminating gas. Bone black prepared in this way is used for refining sugar, oil, etc., and brings a much higher price than bone meal. After the bone black has been used for some time by the various refineries it becomes unfit for their use and is usually sold to the fertilizer manufacturers. Fresh bone black contains about 1 per cent. nitrogen and from 32 to 35 per cent. phosphoric acid.

Ammo. Phos.—See under Sources of Nitrogen.

Tankage.—See under Sources of Nitrogen.

Acid Phosphate—Superphosphate.—This is the chief material supplying phosphoric acid used in fertilizers and may be considered as the basis of the modern fertilizer industry. It is made by mixing together equal weights of finely ground phosphate rock and sulphuric acid. The mixing is done in flat circular pans provided with heavy stirrers, which give a quick and thorough mixing of the rock and acid. From these pans the mixture, still liquid, is dropped into a "hot den" where it solidifies. After remaining in this bin a time the mass becomes solid and may be removed with a pick and shovel or by some mechanical device. The material is then crushed and allowed to "ripen," after which it is used alone or in mixtures as a fertilizer.

The purpose of treating the rock with sulphuric acid is to render the phosphoric acid available and can be shown by the equation

$Ca_3(PO_4)_2+2H_2SO_4+5H_2O$
Insoluble+Sulphuric Acid+Water
Rock Phosphate$=CaH_4(PO_4)_2.H_2O+2CaSO_4.2H_2O$
Water Soluble
Calcium phosphate+Gypsum.

The mixture of mono-calcium phosphate and gypsum is what is called acid phosphate. Acid phosphate contains 16 per cent. available phosphoric acid, although the total phosphoric acid content may be as high as 18 per cent.

Double Superphosphate.—This is a concentrated product produced by treating rock phosphate with phosphoric acid, drying and grinding the product. The phosphoric acid content available varies from 40 to 50 per cent. and the total about 2 per cent. more. Double superphosphate may be regarded as acid phosphate with the gypsum removed. The supply of this material is somewhat limited and it is not in general use.

Other Phosphoric Acid Carriers.—Several other substances carrying phosphoric acid are at present on the market, but they are no better than those we have here listed. The percentage of phosphoric acid is variable and care should be taken to examine closely the analysis tag. If analysis is not given as required by the Fertilizer Act, such materials should not be purchased, and the matter should be reported to the Department of Agriculture, Seed Branch, Ottawa.

Sources of Potash

Potassium Chloride—Chloride of Potash—Muriate of Potash.—This is a natural product, somewhat purified as it is sold. It exists in large deposits in Germany and France, from which we obtain most of our supplies. It is a soluble substance, varying in appearance and colour, and the potash contained in it is instantly available. For fertilizer purposes it is usually sold on a basis of 80 per cent. potassium chloride, equivalent to 50.5 per cent. potash, but may contain as high as 62 per cent.

Potassium Sulphate—Sulphate of Potash.—This substance can be made by the action of sulphuric acid on caustic potash. Some of it occurs naturally in the French and German deposits. In practice, however, it is nearly all made by treating muriate of potash with magnesium sulphate. For fertilizer purposes, sulphate of potash is sold on a basis of 90 per cent. sulphate of potash, equivalent to 48.7 per cent. potash.

Since it is a manufactured product it retails at a higher price than the muriate, so that fertilizer dealers usually state: "In case potash is required as sulphate an additional charge per ton will be made."

Sulphate of potash is instantly available and is preferred for specialized crops such as tobacco and grapes.

SOURCES OF PHOSPHORIC ACID

For Mixing see Mixing Table.

Material	Appearance	Per cent. available P_2O_5	Per cent. Total P_2O_5	When available	Quantity equivalent to 100 lbs. 16% acid phosphate	Remarks
Rock phosphate....	White grey or yellow powder.	0	18-30	Very slowly........	90 lbs. 18% 53 lbs. 30%	Not used greatly in Canada as results are too slow. Possibly of value in a soil which is very low in phosphoric acid.
Basic slag.........	Black grey powder.	Variable, 5-12%....	12-14	Part at once. Rest same as above.	132 lbs. 12%	Bessemer slag better than open hearth. Lime contained has benefit on very acid soil. 80% must pass 100-mesh sieve.
Bone meal, crushed bones.	Grayish white......	Depends on fineness of grinding.	18-24	Throughout the season and after.	88 lbs. 18% 64 lbs. 24%	Good garden material. Used for roses, etc. Too expensive for general farm use.
Steamed bone meal.	Grayish white, quite fine.	Depends on fineness of grinding.	24-28	Throughout the season and after.	64 lbs. 24% 57 lbs. 28%	More quickly available than crushed bone. No odour. Decays very readily.
Bone ash..........	Grayish white......	Variable..........	35-38	Throughout the season.	43 lbs. 35% 42½ lbs. 38%	Not much obtainable for use.
Bone black........	Black.............	Variable..........	32-35	Throughout the season.	43 lbs. 35%	Used generally in mixed fertilizers. Rarely used separately.
Acid phosphate.....	White or grayish. Some has odour.	14-22	14-25	At once...........	100 lbs.	The best and cheapest source of phosphoric acid. Instantly available, easy to handle, economical and satisfactory.

SOURCES OF PHOSPHORIC ACID—Continued

(For Mixing, see Mixing Table)

Material	Appearance	Per cent. available P_2O_5	Per cent. total P_2O_5	When available	Quantity equivalent to 100 lbs. 16% acid phosphate	Remarks
Ammo.-phos.......	White powder......	20-47	20-47	At once...........	80 lbs. 20% 33 lbs. 47%	A concentrated product. Carries nitrogen as well as P_2O_5. Only one grade sold to the public—the 20%. Used for golf greens. The 47% grade sold to fertilizer manufacturers. See nitrogen summary.
Tankage..........	Red to brown material.	Variable...........	10-14	Throughout the season.	160 lbs. 10% 113 lbs. 14%	Carries 6% nitrogen as well. Not used much alone, but is used in making complete fertilizers. Used for golf greens somewhat.
Double superphosphate.	White or grayish powder.	40-50	40-50	At once...........	40 lbs. 40% 32 lbs. 50%	Very concentrated—really concentrated acid phosphate used in less quantities. Used for making high analysis fertilizers such as 5-12-5.

NOTE 1.—If bone products are treated with sulphuric acid the availability of the P_2O_5 is greatly increased. This is done in some cases.

NOTE 2.—In comparing quantities of materials equivalent to 100 lbs. 16% acid phosphate, it must be kept in mind that *total* P_2O_5 is compared, *not* available.

Carbonate of Potash—Potassium Carbonate.—This is a domestic product obtained by the incineration of the mother-liquor by-product of beet sugar manufacture. It contains 50 per cent. potash, which is all available and is preferred for tobacco.

Sulphate of Potash-Magnesia.—This is a potash salt containing not less than 25 per cent. sulphate of magnesia and not more than 2.5 per cent. chlorine. This has been known as double manure salts, but this name is being discontinued. The potash content varies considerably, ranging from 20 to 30 per cent. It is possibly the cheapest form in which potash may be purchased, but is not used here to any great extent.

Kainit.—This is a natural product obtained from French and German deposits and contains potash in the form of potassium chloride. The potash content ranges from 12.4 to 16 per cent., all available. It is used in mixed fertilizers.

Kemfert.—The trade name for a high grade muriate of potash. It is separated from the waters of Searles Lake in California. It usually contains from 58 to 60 per cent. of potash.

Hard Salt.—One of the minerals occurring in the French and German potash deposits. It contains potash as muriate (KCl). The average analysis is about 61 per cent. potash, all available. Rarely seen here.

Feldspar.—A mineral containing silica, alumina, and potash, soda or lime. The potash feldspars are very plentiful and furnish a possible source for potash. The potash in feldspar is insoluble in water and dilute acids, and hence not available to plants. There are a number of chemical methods for converting the potash into water, soluble forms, but these processes are expensive and cannot compete with the French and German deposits. The potash content is variable.

Kelp.—A species of seaweed which occurs in many parts of the ocean. At one time a good deal of potash was obtained from kelp and the harvesting of this seaweed was a thriving industry on the coasts of Scotland and Norway. The giant kelps which grow along the coast of California were harvested during the war to a limited extent and turned into fertilizer material. It contains from 15 to 20 per cent. potash.

Tobacco Stems.—The stems and leaf ribs of tobacco are ground and used as a fertilizer material containing nitrogen and potash. The nitrogen varies, but will average between 1½ to 3 per cent. while the potash ranges from 4 to 9 per cent. This potash does not become available until the material decays.

Wood Ashes.—This is a satisfactory and cheap source of potash. In an unleached condition the potash content is about 5 to 10 per cent. Leached ashes, of course, contain much less, depending on the amount of leaching. Besides potash, wood ashes also contain much lime and all ashes produced on the farm should be carefully preserved and returned to the land.

Potash Ammonium Nitrate.—This is one of the newer synthetic nitrogen compounds produced by the Badische-Anilin-Soda-Fabrik of Germany, containing beside 15.5 per cent. nitrogen about 27 per cent. potash. It is used largely in Germany where potash is more generally used than here, but in Ontario its use is limited except where both potash and nitrogen is required. There may be a use for it for tobacco and for onions on a muck soil. All the nitrogen and potash is available.

Material	Appearance	Per cent. available K_2O	Form in which potash is present	Quantity equivalent to 100 lbs. muriate of potash, 50% K_2O	Remarks
Muriate of potash......	White or gray crystals	50-62	Muriate	100 lbs.	Best genetal source of potash. Not suited for tobacco and some claim not for potatoes. All potash available.
Sulphate of potash......	White crystals.......	48.7	Sulphate	105 lbs.	Higher in price than the muriate. Preferred for tobacco. All potash available.
Carbonate of potash....			Carbonate		
Sulphate of potash-magnesia (double manure salts).	Light coloured crystals	20-30	Sulphate	250 lbs. 20% 166 lbs. 30%	Used largely in making mixed fertilizers. Not sold to general public to any great extent.
Kainit...............	Light coloured crystals	12.4-16	Muriate	400 lbs. 12.4% 312 lbs. 16%	Same as sulphate of potash-magnesia.
Kemfert.............	White...............	58-60	Muriate	86 lbs. 58% 83 lbs. 60%	High grade muriate of potash. An American product.
Hard salt.............	White...............	16	Muriate	312 lbs.	Natural European mineral. Used in manufacture of mixed fertilizers.
Feldspar.............	Variable............	Variable	Silicate		A natural product, but cannot be made available so as to compete with European goods.
Kelp.................	Seaweed............	Total 15-30	Organic		Used on sea coasts. Rarely seen in Ontario.
Tobacco stems.........		Total 4-9	Organic	1,000 lbs. 5%, stems	By-product of tobacco factories.
Wood ashes...........	Grey...............	5-10	Carbonate	1,000 lbs. 5% 500 lbs. 10%	Excellent material. Should be saved on every farm.
Potash amm. nitrate....	White crystals.......	27	Nitrate	185 lbs.	Also contains nitrogen and is not bought for potash alone. Little used yet in this country.

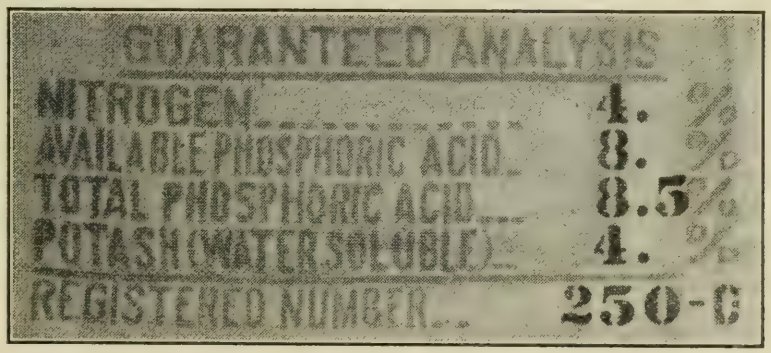
THE FERTILIZER ACT

The Federal Department of Agriculture has gone to considerable trouble and expense annually to make certain, when a farmer purchases a fertilizer having a certain analysis, that he actually obtains what is represented on the tag. The Fertilizer Act covers this point fully, and is designed for the protection of the user of fertilizers. It is not the purpose of this bulletin to go into the details of the act, but merely to point out some of the most important points, with respect to the analysis.

In the first place every container of fertilizer must be marked as follows, either on the container itself or on a tag attached thereto.

(a) the name and address of the manufacturer or importer.
(b) brand name.
(c) registration number and designation of year of issue.
(d) guaranteed analysis stating separately in minimum percentages only.

1. Water soluble nitrogen.
2. Total nitrogen.
3. Available phosphoric acid.
4. Total phosphoric acid.
5. Potash soluble in water.
6. In the case of basic slag or natural rock phosphate or a mixture of both the fineness thereof.
7. Whenever present in fertilizer the percentage by weight of leather, hoof, horn, hair, wool-waste, peat, garbage, tankage or any similar organic material unless it has been treated in such a way as to make the nitrogen or phosphoric acid or potash therein available as determined by methods of analysis to be prescribed by regulation.



GUARANTEED ANALYSIS
NITROGEN.......... 4. %
AVAILABLE PHOSPHORIC ACID.. 8. %
TOTAL PHOSPHORIC ACID..... 8.5%
POTASH (WATER SOLUBLE).... 4. %
REGISTERED NUMBER..... 250-C

Showing how the analysis of a fertilizer is marked on the bag itself or on a tag fastened to it. Buy by analysis only.

It is seldom that the fertilizer tag is as complicated as would be indicated by the above regulations. In the ordinary fertilizers sold number 7 rarely appears. Number 6 applies to basic slag and rock phosphate alone. In the mixed fertilizers, however, the points of particular interest are (1) water soluble nitrogen. This is a measure of the availability of this element. If water soluble the nitrogen will become available very quickly and therefore truck gardeners who wish quick action should specify that the nitrogen must be water soluble. It would be advisable to go further and specify that the nitrogen must be in the form of nitrates. For example ammonium sulphate and nitrate of soda are both soluble in water, but the latter is available at once while the former may not be available for from a few days to several weeks, depending on weather conditions.

The total nitrogen is also important as it all becomes available in time and generally speaking we can regard all the nitrogen in the average mixed fertilizer as available. Further since it is the most expensive element we have to purchase, it is necessary to pay particular attention to it.

Regarding the phosphoric acid content the principal part of the analysis is the percentage available. The total content is of interest in basic slag and rock phosphate, but we demand that the phosphoric acid is mixed goods be available.

The potash, since it is water soluble is available so there is no need of any information as to the total content.

WHAT ANALYSIS MEANS

The three points of interest are, then:—

(1) total nitrogen; (2) available phosphirc acid; (3) water soluble potash. Hence when speaking of a mixed fertilizer we call it a 2-12-2 or a 5-10-5 or any other analysis. The first figure is of course the total nitrogen; the second the available phosphoric acid and the third available potash. Generally speaking it does not matter in what form the three elements occur. The fertilizer act requires that they be available.

BUY BY ANALYSIS ONLY

In purchasing a fertilizer then, the only basis of choice is the analysis. One may have a liking for some particular brand, but the principal point is the actual plant food obtained and this is stated on the analysis. For example a farmer might require only phosphoric acid and potash and therefore his requirements would be met by an 0-12-4 fertilizer. He would be very foolish to purchase the same as his neighbour used, which might contain as high as four per cent. nitrogen say a 4-8-4. Therefore, before any farmer purchases fertilizer he must study his requirements and buy that fertilizer which suits his particular case. This he can only do by buying by analysis.

FACTORS AFFECTING THE CHOICE OF FERTILIZER

There are many factors which determine the kind and amount of fertilizer to use under a given set of conditions and the extent to which this fertilizer will influence crop yields. Some of the factors are as follows:—

1. Fertility of the soil.
2. Annual rainfall and its distribution.
3. Length of growing season.
4. Feeding habits of crops.
5. Fertilizer requirements of crops.
6. The soil reaction or need of lime.
7. The type of farming.
8. The cropping system or rotation.
9. The intensity of culture.
10. The method of applying fertilizer.
11. Insect pests and plant diseases.
12. Quality of seed.
13. Thoroughness of soil preparation and cultivation.

The relative effects of these factors will vary from Province to Province and from farm to farm, but they are all of more or less importance in nearly every instance. Obviously they cannot be listed in order of importance. A brief discussion of each follows:—

NATURAL FERTILITY OF THE SOIL

The number of soil types in the province is quite large, though many of them are quite similar in so far as their response to fertilizers is concerned. Nevertheless soils vary widely in fertility. They vary all the way from sandy soils deficient in all the essential plant foods to thin clay loams rich in potash but low in nitrogen and phosphoric acid, and muck soils rich in nitrogen and deficient in all of the minerals. Moreover many soils that were fertile 50 to 100 years ago are now in serious need of fertilization. Thus we find within the same type soils that give only moderate returns with fertilizers, and others that require liberal applications for the production of satisfactory crops.

RAINFALL.—This does not affect Ontario to any great extent although where the summer is very dry the results obtained from fertilizers will be very uncertain. Even where the total annual rainfall is 30 to 40 inches, summer drouths are frequently severe enough to seriously reduce crop yields.

THE GROWING SEASON.—There is a vital relation between length of growing season and fertilizer practice. This is particularly true of nitrogen. In this province we have a short growing season, shorter the farther north we go—and the soil nitrogen does not become available early in the season. Hence for early crops it is generally considered necessary for us to use nitrogen as nitrates exclusively. Furthermore, the decrease in total soil nitrogen is not so great in our northern sections, hence we do not need to purchase as much nitrogen as do the southern states. As a result fertilizer recommendations for southern United States cannot be applied to Ontario.

FEEDING HABITS OF CROPS.—There is a great difference in the feeding habits of crops. Some are shallow rooted or surface feeders, as for example small grains, many grasses and vegetables. Corn on the other hand is a deep rooted crop, its roots being distributed through the first two, three, or four feet of soil. Alfalfa is specially noted for its deep roots which often penetrate the soil to almost unbelievable depths. The depth and nature of the root system of the crop has a definite relation to fertilizer practice.

The feeding power of crops also varies greatly. This is a technical subject involving the chemistry of cell sap and other related factors. It has been shown that some crops are able to secure a greater proportion of their necessary requirements of plant food from relatively unavailable sources than others. Sweet clover for example will thrive in very poor soil, providing it is not acid.

FERTILIZER REQUIREMENTS OF CROPS.—Crops vary in their response to the different elements of plant food and this has given rise to many brand names in fertilizers. Potatoes and tobacco for example respond to potash. Grain fertilizers should be high in phosphoric acid and relatively low in nitrogen and potash. Fruit trees generally respond to nitrogen and not to the other two. Grasses require high nitrogen while legumes require phosphates and potash.

THE SOIL REACTION.—Many of our soils are acid, so acid in some cases that fertilizers cannot be used to the best advantage without lime. For example, potatoes do well and are much less likely to be scabby, on a soil that is slightly acid, whereas red clover, alfalfa and many other crops would not do so well on such soil. Some fertilizer materials tend toward acidity, while others tend to make the soil alkaline. Some, for example acid phosphate, do much to counteract the injurious effects of soil acidity. A proper understanding of the problem of soil acidity is therefore essential for intelligent fertilizer practice. This subject is covered in Bulletin 313, Soil Acidity and Liming.

THE TYPE OF FARMING.—No other factor has greater influence on the choice of fertilizer than this. Contrast a dairy farm where the only product sold is milk or cream and where feed is purchased in quantities, with the farm specializing in seed potatoes or canning produce. Again contrast the tobacco producing areas of Essex County with the apple producing section of Durham and Northumberland. Even compare different types of farms in the same community and it will readily be seen that the best fertilizer practice for each will be materially different from the others.

THE CROPPING SYSTEM OR ROTATION.—This factor is closely related to type of farming discussed above, but even on farms of the same type the cropping system may be sufficiently different to affect materially the use of fertilizers. Thus we find many distinct cropping systems on all types of farms. One potato grower may follow a three year rotation of potatoes, oats and clover, while another may raise potatoes continuously on the same land with rye and vetch as a cover crop for green manure.

The extent to which legumes are grown is a very important factor in determining the fertilizer practice and one that is generally recognized. No one who knows what he is about would recommend the same fertilizer for potatoes following clover or alfalfa, that he would recommend for the same crop following timothy or oats. It is admitted that the farmer should grow clover before corn, but if he wants to grow corn after timothy he should have a fertilizer recommendation which will fill his needs.

THE INTENSITY OF CULTURE.—This factor is becoming of increasing importance as time goes on. City population is increasing faster than rural and it will no doubt continue to do so. Ontario is destined to become largely industrial and the greater the urban population the greater the demand for food stuffs. Consequently, more intensive type of agriculture will be profitable in this province in the future, and other conditions being equal the rate of application of fertilizers will be higher.

METHOD OF APPLYING FERTILIZER.—This is a matter of considerable importance in determining the effectiveness of fertilizer. There are many methods of applying fertilizer which will be dealt with in detail later on. It has been shown, however, that the method of application will greatly effect the yields of the crop. A small quantity properly applied is often of as great benefit as a large quantity improperly applied. It has been shown also that the germination of seed may be delayed or prevented by the wrong method of application of fertilizer. Improvements in machinery designed to apply fertilizer and seed at the same operation, are very necessary.

INSECT PESTS AND PLANT DISEASES.—Crop losses from diseases and insect pests are heavy, running into millions of dollars annually. Methods of controlling these have in many cases been worked out and applied. It sometimes happens that insect damage destroys a crop, in the production of which considerable expense had been incurred for fertilizer. This often prejudices a man against fertilizers. On the other hand fertilizers often afford a means of avoiding or preventing insect damage. The Hessian fly may be eliminated by late sowing, but, in order to bring the wheat along so it may withstand the winter, fertilizers are necessary. Potash plays an important role in the prevention of plant diseases such as leaf scorch (caused by small water supply) rust, mildew, potato blight, stripe disease of tomatoes and others. It has been definitely proven that many of these diseases can be reduced, if not prevented, by proper fertilization.

THE QUALITY OF SEED.—This factor in successful crop production needs no argument. The point is that the man using poor seed cannot possibly obtain all the benefit from fertilizer used. Good seed is a first essential.

Soil Preparation and Cultivation.—This is another factor affecting the successful use of fertilizer that needs only to be mentioned. The better the work of plowing and preparing the seed bed and of cultivating the crop is done, the more profitable the use of fertilizer will be.

All the above conditions affect the choice of fertilizer and limit its effectiveness so the choice and use of a fertilizer is not guess work, but is a problem requiring serious consideration and a great deal of scientific knowledge. In this respect the Department of Chemistry, O.A.C., plays an important part in agriculture in the province and farmers are urged, in their own interests, to consult the department before using fertilizers.

HOME MIXING vs. FACTORY MIXED

The question of whether or not it pays a man to mix his own fertilizers is deserving of some consideration. The advantages of home mixing may be stated as follows:—

1. A cash saving of from $8 to $12 per ton.
2. Enables a farmer to make exactly the mixture he desires.
3. Enables him to have the nitrogen and potash in the chemical form in which he requires them.

On the other hand the disadvantages are:—

1. Difficulty in securing raw materials for mixing.
2. Home mixed fertilizers are rarely as well mixed or as finely ground as prepared mixtures.
3. Requires labour, and equipment.
4. Without thorough knowledge of what happens, losses may be incurred and unexpected occurrences such as caking may happen.

Further, the fertilizer firms are willing to co-operate with the farmer. If he states he wants the nitrogen as nitrate or the potash as sulphate or makes other specifications, most of the companies will meet him half way, and give him what he wants. Therefore considering all factors it is generally considered advisable for the average purchaser to purchase ready mixed fertilizers. For the benefit and assistance of those desiring to do their own mixing, instructions are herewith given.

Mixing Fertilizers on the Farm

The process of mixing fertilizers on the farm does not require much complicated equipment. It may be performed in any place with a smooth firm floor, by means of an ordinary square mouthed shovel, a screen and a tamper, with which to break lumps. It is not advisable to use fanning mill screens but to mount one of suitable mesh on a frame as illustrated. The one in use at the Department of Chemistry, O.A.C., has thirty-six equal sized openings to the square inch and has proven very satisfactory. The only additional equipment necessary is a set of scales such as is found on every farm.

The materials to be mixed are assembled on the mixing floor, and the one which is in greatest quantity—generally acid phosphate, emptied out. Since each bag weighs 125 lbs. it is an easy matter to approximate the weights even without scales. The other materials are crushed, if lumpy, screened and spread evenly over the heap. The whole mass is then mixed with a shovel in the same way that wheat is turned, when treating with formaldehyde. Since no filler or conditioner is added there may be caking occur after mixing, so that the material should be applied to the land as soon as possible after mixing, certainly within two or three days. As to quantities of materials required to make a mixture of a definite analysis let us take a concrete example. Suppose for instance we wish to make a fertilizer having the analysis 2-12-2. The following calculations illustrate the method.

$$\text{Total amount of nitrogen } \frac{2}{100} \times 2000 = 40 \text{ lbs.}$$

$$\text{“} \quad \text{“} \quad \text{“ } P_2O_5 \quad \frac{12}{100} \times 2000 = 240 \text{ “}$$

$$\text{“} \quad \text{“} \quad \text{“ } K_2O \quad \frac{2}{100} \times 2000 = 40 \text{ “}$$

Let us choose as a source of our materials ammonium sulphate, 20 per cent. N., acid phosphate 16 per cent. phosphoris acid and muriate of potash 50 per cent. potash.

We require 40 lbs. of nitrogen.

This will be supplied by $40 \div 20 \times 100 = 200$ lbs. ammonium sulphate.

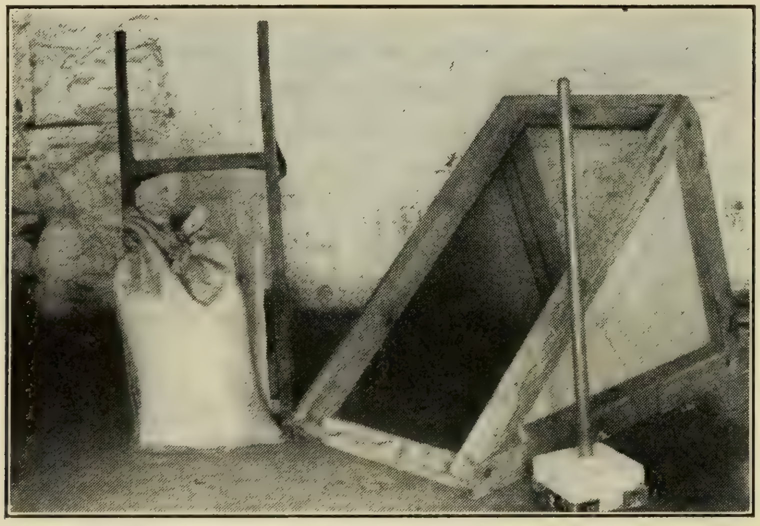
We require 240 lbs. P_2O_5.

This will be supplied by $240 \div 16 \times 100 = 1{,}500$ lbs. acid phosphate.

We require 40 lbs. potash.

This will be supplied by $40 \div 50 \times 100 = 80$ lbs. muriate of potash. Total weight, 1,780 lbs.

The manufacturer making up this fertilizer would add to it during grinding and mixing 220 lbs. of filler such as sand, peat, or some other material which will make the weight up to a ton, and keep the mixture more open and less liable to cake. This is sometimes known as a conditioner.



Equipment necessary for home mixing of fertilizers.

In farm mixing this is rarely added, and as a result the amount to be applied of the above mixture has to be cut down. For example if a man wished to use 400 lbs. of a 2-12-2 he would only use 356 lbs. of the above mixture to obtain the same results. This is calculated by dividing the total number of pounds of material mixed by 2,000 and multiplying the result by the number of pounds of the ready mixed fertilizer, that is desired per acre. In this matter any points not clear will be explained to any farmer who wishes further advice on the subject. Write to the Department of Chemistry, O.A.C., Guelph.

COMPATABILITY OF MATERIALS

In home mixing it is necessary to know what chemical reactions take place when two materials are mixed together. For example lime, or any other basic reacting substance, mixed with ammonium sulphate will always cause a loss of nitrogen, liberating it as ammonia. Any form of lime mixed with acid phosphate causes it to revert, that is, changes it into an insoluble form. Potash bearing compounds mixed with basic slag, cake in a few hours. Therefore, before a man mixes fertilizers it is necessary to know what substances may be mixed without loss, or caking. This is shown by the following table. It will be noted that under acid phosphate it is considered undesirable to mix any nitrate with that material. This is, of course, where any dampness exists. Many ready mixed goods contain nitrate and it is highly desirable that they should, but the amount present is generally quite small, rarely over one or one and a half per cent. nitrogen. Further there is generally a filler used which assists in keeping the mixture dry. If left standing or if it becomes damp there is almost certain to be unsatisfactory results.

FERTILIZER COMPATABILITY

Fertilizer	Should not be mixed with	Mixed just before using with
Acid phosphate...........	Lime, any form. Basic slag. Sodium nitrate. Calcium nitrate. Ammonium sulphate nitrate. Potash ammonium nitrate.	Might be mixed with nitrates if used immediately, with some material to prevent caking.
*Lime, $Ca(OH)_2$...........	Superphosphate. Ammonium sulphate. Bone meal. Barnyard manure. Ammonium sulphate nitrate. Potash ammonium nitrate. Urea.	Kainit. Potash salts.
Ammonium sulphate. Ammonium sulphate nitrate. Urea. Potash ammonium nitrate.	Lime. Basic calcium nitrate. Basic slag.	
Potassium salts.	Basic slag.	
Sodium nitrate.	Acid phosphate.	
Bone meal.		
Barnyard manure. Sheep manure.	Lime, $Ca(OH)_2$.	
Basic slag.	Potash salts. Ammonium sulphate. Superphosphate. Ammonium sulphate nitrate. Urea. Potash ammonium nitrate.	
*Crushed limestone, $CaCO_3$ or $MgCO_3$.	Acid phosphate.	

*Slaked lime and crushed limestone are not fertilizers, but are included in this list on account of the fact that they are common materials.

THE EFFECT OF FERTILIZER LASTS MORE THAN ONE SEASON

The question, "How long will the effect of fertilizer last?" is one which many farmers ask. There has been a limited amount of work done on this phase of fertilizer work, but generally it can be answered, "Given a fairly heavy application, the effect will persist for three years." There are four principal factors affecting the length of time; the first is the material used, second the amount applied; third, the method of application, fourth, rainfall.

If easily soluble material such as nitrate of soda, sulphate of ammonia or potash compounds are used in small quantities it is doubtful if the effect will persist more than one season as the portion which is not used by plant growth will likely be leached out. Even though ammonium sulphate is fixed by soils, as soon as it is converted into nitrates, leaching will occur. With the phosphatic materials, however, there is no leaching, the phosphoric acid being firmly retained by the soil so that what is not used in one season remains for the succeeding crops.

Showing effect on oats of fertilizer applied on potatoes the previous year.

Showing clover on part of field fertilized with tobacco five years previously with 1,000 lbs. 4–8–4.

The amount applied has a good deal to do with whether or not results will be noted the second year. A fertilizer applied at the rate of say, to 150 pounds per acre will not likely show any effect the second year, but if applied from 300 to 800 pounds, an effect may persist over two or three years.

The method of application has possibly a little to do with lasting effects. This may be because the effect can be more clearly seen. Fertilizers applied in rows are more likely to show effect the second year, but this may be regarded as the rate of application, a heavy application for a few inches and then none at all.

If the season in which the fertilizer is used is very dry, the fertilizer remains more or less untouched by the crop. As a result the effect that season will be limited. The next season, since the fertilizer has gone into solution, very evident effects will be noted.

Experiments carried on by the Department of Chemistry, show where wheat has been fertilized, followed by clover, that not only has the yield of wheat been increased approximately fifty per cent., but the clover first year was increased 30 per cent. and the second year 27 per cent. On potato experimental work on potatoes the fertilized rows can easily be seen the second year.

MIXED FERTILIZERS vs. ACID PHOSPHATE

The relatively greater increase in the use of straight acid phosphate than of mixed fertilizers during the last decade has been so marked that it is interesting to look into the question to some extent. The immediate cause of this more rapid increase in the use of acid phosphate was largely due to the high price of nitrogen and potash directly related to the war.

Irrespective of the war, however, there had been for some years a marked tendency in the direction of the use of acid phosphate alone, in spite of extensive advertising of the fertilizer manufacturers. Several factors were operative in bringing about the increased use of acid phosphate alone. One of these was the competition of western virgin soils which produced heavily without any fertilization at all. The eastern farmer, forced to compete had to cut his fertilizer costs, and as a result used straight acid phosphate. A second factor is co-operative buying where it greatly simplified matters to purchase car loads of uniform materials, while a third was the difference in price between acid phosphate and a complete fertilizer.

Farmers who give the matter any thought recognize that the complete fertilizer should be more effective than acid phosphate in boosting the yields of crops. The problem for them is one of the cost of nitrogen and potash in the bag as compared to the expense of taking these elements from the air and the soil. As a result the strictest economy was necessary in the east so long as western farmers exploited the stored up fertility of their soils. When it was discovered that "phosphated manure" (40 lbs. of acid phosphate per ton of manure, applied with it) would increase yields remarkedly, the use of straight acid phosphate received a great impetus. When it was established that legumes were capable of fixing atmospheric nitrogen, it appeared probable that the nitrogen requirements of the other crops in the rotation might be satisfied by the introduction of a legume crop as often as once in three years. Assuming that the larger part of these crops was fed on the farm it seemed logical to believe that if manure were protected from the weather, both the nitrogen and potassium requirements of large crop yields could be met. This is true in many cases. The only remaining needs, then, were lime and acid phosphate.

It is doubtful whether complete fertilizers can be profitably used in place of acid phosphate in general farming where there is a plentiful supply of manure. At the same time under conditions where such supply of manure is not maintained complete fertilizers will find a place. Then there is the factor of economy of fertilizer manufacture. Since the low grade fertilizers (such as 1-8-1) have been discarded, and the total number of mixtures offered for sale, considerably reduced, the production of fertilizers is more economical at the present time, and economy in production is reflected in the retail prices.

It will probably never be economically possible to satisfy the entire soil requirements of the cereal and hay crops from the fertilizer bag. The small quantities of nitrogen and potash which may be applied can only be considered as supplementary to such amounts of these elements as can be extracted from the air and soil by good soil and crop management. The use of acid phosphate, limestone, growing legumes, saving manure, and the improvement of the mechanical processes by which the quantities of these elements in circulation in the soil are increased must receive more consideration.

The fertilizer manufacturer views with disquiet the demand for acid phosphate alone. But at the same time it is a good beginning. It is known that phosphoric acid will give paying results all over Western Ontario on almost any crop. The man who has never used fertilizer before, and knows nothing of it will therefore do well to use acid phosphate alone at the start. Then if he finds good results his own curiosity will encourage him to experiment with nitrogen and potash in order to determine whether they may be of benefit to him. If they are, then he will purchase a complete fertilizer—if not he will continue the use of acid phosphate.

Since phosphoric acid is the most important element, it is necessary to produce fertilizers containing a high percentage of this constituent. Even when nitrogen and potash has been added there is no reason why the percentage of phosphoric acid should be dropped. Therefore, the manufacture of a 2-16-2, a 3-16-3 or even a 4-16-4 would be welcomed.

This would give the excellent results of straight acid phosphate and probably over top it by the additional effect of the nitrogen and the potash. Another point is that *one* ton of 4-16-4 is equal to *two* tons of a 2-8-2 now sold. This means less grinding, bagging and freight costs and therefore, a cheaper fertilizer when the cost per unit is calculated.

We may conclude then, that in many cases acid phosphate alone is the best fertilizer to use, but there are many other conditions when the use of a mixture of two or more constituents is desirable and, furthermore, is warranted. Those special conditions will be dealt with under a discussion of the choice of fertilizer.

RESIDUAL EFFECTS OF FERTILIZERS

The question often arises and the statement is often seen that fertilizers "burn up the soil." Just what is meant by this statement it is very difficult to say. The idea appears to be, however, that fertilizers have some residual effect on the soil that is detrimental to soil fertility, and subsequently lowers crop yields. This idea is partly correct. At the same time long continued fertilizer treatment has shown that the yield of wheat can be kept up over a long period of years by the use of mineral fertilizers alone. This has been demonstrated at Rothamsted, England, and in Ohio. The Ohio experiment has only run a matter of ten years, however. The authors of this bulletin do not feel that the evidence up to date warrants a farmer depending on fertilizers alone, but rather to use fertilizers as a supplement to barnyard manure.

Other investigations have shown that certain fertilizer materials do have a well defined action on the soil when used over a long period of years. This action may be beneficial or detrimental according to the effect desired. For example the long continued use of sulphate of ammonia on soils which are neutral or acid brings about a strongly acid condition which is very harmful to many crops, but which is highly desirable on golf greens or lawns. Nitrate of soda on the other hand brings about an alkaline reaction in the soil. Acid phosphate, although in many cases acid itself, actually exerts an alkaline effect on the soil—at least it assists in overcoming the effects of soil acidity. Potash bearing materials have little effect either way although they are regarded generally as slightly increasing acidity.

It has been claimed by some that one constituent alone tends to deplete the soil of fertility. This idea originated in the fact that when one element alone is added the increased growth draws more heavily on the other plant food constituents of the soil, thereby causing a deficiency for the succeeding crop. This is of very little interest and does not apply to ordinary farm conditions. Supposing nitrogen alone is added to a soil. This of course stimulates growth and therefore there is a greater draft on the other plant food in the soil. But if this material is fed on the farm the amount of manure returned is greater, hence the greater removal is more or less balanced. In market garden work the whole product is sold so there undoubtedly is a loss of plant food. At the same time the product is on the market earlier, a higher cash return is received, and the plant food can be purchased as fertilizer and still leave the producer ahead of the game.

The use of acid phosphate alone is altogether different. Phosphoric acid does not stimulate growth as nitrogen does, and consequently there is not such an increased draft on the soil supply. All our soils are becoming deficient in phosphoric acid and by the application of phosphates we simply supply an element which is deficient. There can be little or no harmful effects arise from the use of acid phosphate alone.

EFFECT OF FERTILIZER MATERIALS ON SOIL REACTION WHEN USED CONTINUOUSLY FOR A PERIOD OF YEARS.

Material	Effect
Nitrate of soda	Alkaline.
Ammonium sulphate	Acid.
Ammonium sulphate nitrate	Acid.
Blood meal, tankage and other organic compounds	Little or no action.
Ammo-Phos	Acid.
Calcium nitrate	Little or no action.
Sulphur (natural)	Acid.
Acid phosphate	None. Assists in overcoming effect of acid soil.
Rock phosphate	None.
Basic slag	Alkaline.
Bone meal	None.
Potash compounds	Very slight acid.

METHODS OF APPLICATION OF FERTILIZERS

Fertilizers in the first place were generally applied by hand, even up to comparatively few years ago. This entailed so much labour and since larger areas have been fertilized in recent years, machinery had to be designed for the purpose of applying fertilizers. Many of the ordinary grain drills are equipped with a fertilizer attachment which delivers the fertilizer down the same tube as the seed, and therefore in direct contact with it. Potato planters, designed to apply fertilizers drop the fertilizer in the bottom of the trench where it is mixed slightly with soil before the potato set is dropped on top of it. Corn planters and other seeding machinery are also designed to distribute fertilizer but in the majority of cases the material is placed in contact with the seed. This does no harm providing small quantities are used, say up to 300 pounds per acre, but if heavier applications are made the germination of the seed will be seriously affected, particularly in a dry season. Even when moisture is present in fair quantities, if heavy applications are made, the germination may be retarded.

This is due to the fact that the seed cannot absorb sufficient water to start germination and therefore lies in the soil until the rains spread the excessive quantity of fertilizer, throughout the soil.

There has been only a limited amount of investigation done on the method of application of fertilizers, but it is beginning to receive more attention at the present time.

It is recognized that fertilizer placed in direct contact with the seed often proved injurious to germination of seed and to the sprouting of potatoes. For general cereal crops where fertilizer is rarely used above four hundred pounds per acre, and generally speaking, in forms which are not readily soluble in water, the present method of application along with the seed is probably as good as any. It is certainly better than broadcasting before seeding since the plant food contained in the fertilizer is right where the young plant can get at it.

In regard to potatoes, however, there are serious objections to the placing of fertilizer directly under the set even if not in contact with it. There is a great concentration of plant food right under the plant. As a result the root system does not need to cover a greater area in order to obtain its requirements. Consequently a small root system is developed. Then if the season is dry, the small root system cannot obtain sufficient moisture to supply the plant and as a result the yield is lessened. On the other hand if the fertilizer be broadcasted before seeding, although a larger root system is produced, the effect of the fertilizer is reduced. Undoubtedly there will be a pronounced effect the year following, but the effect is desired on the potatoes—not on the succeeding crops.

The potato sprout is particularly sensitive to changes in the concentration of the soil solution. Hence if fertilizer be applied *above* the potato set injury is almost certain. The only position left then is to one side of the set and preferably a little lower. This is what is termed the side lower plane position which is the most desirable method of application with potatoes, corn, or any other crop planted or sown in hills or rows. The different positions are illustrated on page 43.

With corn, some planters are designed to place the fertilizer behind the hill. Frequently they go out of order and the fertilizer comes in contact with the seed with injurious effects. Other planters put the seed in contact with the fertilizer which is of course entirely wrong, as corn sprouts are very sensitive.

The method of application has considerable to do with the quantity used. For example 200 pounds of a 2-12-2, drilled in with grain, gave as good results as 400 pounds of the same broadcasted.

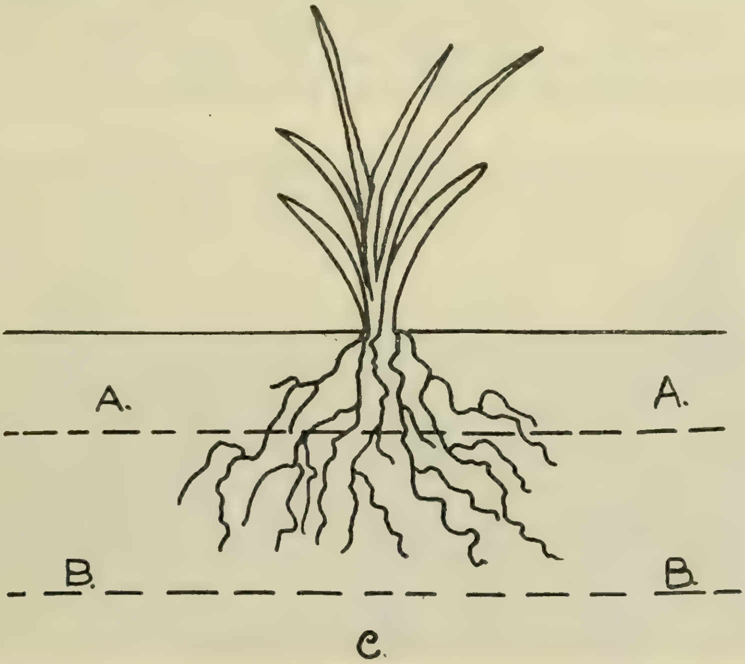
In hill applications, a much smaller quantity is as effective as a greater quantity applied broadcast, providing of course, it is not applied in such a way as to be injurious to germination.

At present, however, machinery is not designed for the greatest efficiency in application of fertilizers, but this problem is being investigated and we may look, before many years, for new designs of fertilizer applying farm implements. For example for the corn crop, either for seed or canning, the chief effect of fertilizer is to give the crop a good start in the spring, rather than to provide plant food over the whole season. For this purpose soluble fertilizers applied during the first two cultivations would prove very beneficial. The same is true of mangels, sugar beets and similar crops, even potatoes. It is therefore, possible that in the future we may have cultivators equipped with fertilizing attachments. This phase of the work requires a great deal of investigation, but some is being done and in the next few years interesting results will be available.

GENERAL PRINCIPLES OF FERTILIZATION

In using a fertilizer for any purpose one must always keep in mind the various factors, already enumerated which may alter the effectiveness of that fertilizer. These are numerous but should always be given consideration.

There are four great principles of soil fertility, however, which are easily kept in mind, Drainage, Lime, Organic Matter and Phosphorus. These we sometimes call the "Big Four" of successful soil management. Each has been discussed previously in this bulletin so we shall not mention them further except the last one, "phosphorus." Quite often this element is called "Phosphoric Acid" and is possibly better known under that name. We must always keep in mind that manure does not supply sufficient of this element to replace that removed by crops so that the supply in the soil is gradually becoming depleted. Nature makes no effort to replenish the supply either, so we must purchase it. There are many forms in which it may be purchased, already described, and the purchaser must decide on what forms he desires.



Showing location of fertilizer with respect to root system.
B is the best position.
A—Side upper plane. B—Side lower plane.
C—Beneath plant.

It must be kept in mind also that the majority of Ontario soils respond remarkably to the use of phosphoric acid, so much so that in the opinion of this Department no matter what mixed fertilizer be bought, if phosphoric acid be present the content should be above 10 per cent.

We can very often supply nitrogen and organic matter by the use of legumes. We can further keep up the organic matter by the use of manure and green manure crops. We can purchase the phosphoric acid and drain if drainage is required. Even under these conditions it may be desirable to use the other two elements, nitrogen and potash in a fertilizer and therefore the fertilizing of a few crops is given in detail. It would be impossible of course to give fertilizing directions for all crops under all conditions and a knowledge of the principles involved is much more to be desired than directions. This is the purpose we have in mind in writing this bulletin, rather than to attempt to tell how to fertilize every crop.

FERTILIZING FOR WHEAT AND CLOVER

The largest factor in determining the cost of producing a bushel of wheat is yield per acre. Low yields mean high production costs. This is because many of the costs are fixed whether the yield is high or low. Land rental, seed and labour for ploughing, seeding and harvesting are practically the same whether the yield is eight or 38 bushels to the acre. High yields of wheat are obtained only when the crop has an adequate supply of plant food and when good cultural methods are practised. Fertilizer on wheat produces more bushels. It reduces the cost per bushel and increases the profit per acre. Fertilizers also improve quality and raise the grade and price received.

The effect of acid phosphate on fall wheat.
Left—Untreated. Right—Acid phosphate.

MORE BUSHELS PER ACRE

The lime and phosphate experiments carried on by the Department of Chemistry, O.A.C. in 1922, '23, '24 and '25 have definitely proven the value of phosphoric acid as an aid to fall wheat. These experiments were laid down, three to a county in a total of twenty-four counties. Briefly the purpose of the experiment was designed to show the effect of lime and phosphoric acid on the yield of wheat and on the resulting clover crop. The plan of the experiment included four plots each one-half acre. Number one plot was untreated. Number two received lime alone: number three lime and acid phosphate and number four complete fertilizer. The lime was applied at the rate of two tons per acre, acid phosphate 400 pounds and the complete fertilizer 300 pounds. Very striking results were seen. In 1923 the wheat yield was increased by the use of acid phosphate 54.68 per cent. In 1924 it was increased 31.9 per cent. In 1925 it was increased 11.1 per cent. The clover yield following the 1923 wheat was increased by lime 40.78 per cent. Lime and acid phosphate gave an increase of 64.77 per cent. In 1925 lime increased the clover 19.9 per cent., lime and acid phosphate 65.9 per cent. These results are definite proof of the lack of phosphoric acid in Ontario soils and the effect of applying the same as acid phosphate.

It is almost certain then that phosphoric acid will give returns on fall wheat and for clover lime and acid phosphate is as certain of results. Several authorities claim that potash is necessary for clovers and is generally productive of good results. So far on our experiments in Ontario we have not seen any great evidence of the value of potash for clover, but it is quite possible that the addition of potash, say four per cent., would give fair results.

FERTILIZING THE CORN CROP

Corn is known as a heavy feeder. A 60 bushel crop of corn removes from the soil 88 pounds nitrogen, 13 pounds of phosphorus and 42 pounds of potassium. There is no possibility of growing a crop of this size without the plants taking up these quantities of the three primary plant foods from every acre. Further these amounts of material must be in an available condition, which necessitates a high state of fertility.

There is little doubt that the best fertilizer for corn, in so far as it is obtainable, is barnyard manure. The difficulty is that it is rarely available in sufficient quantities. There is one other difficulty with manure and that is its rather low content of the element phosphorus. Ontario soils, as mentioned before, are deficient in this element and it has been found profitable in many cases to reinforce manure with it. Various experiments have been carried on along this line, those of Ohio being best known. In Ohio experiments 40 pounds of acid phosphate has been in one case added to each ton of manure and in another 40 pounds of rock phosphate. Both have materially increased yields but the best returns have been obtained from the acid phosphate. From these and similar experiments at other stations it seems safe to recommend an application of acid phosphate along with manure on practically all soils of average or less than average fertility. There is little doubt that such application will give good results. But most farmers have not sufficient manure to cover the corn area and the question arises as how to best fertilize the remainder of the land. It is here where commercial fertilizers become important. The selection of a fertilizer is not easy. On soils of medium fertility the treatment above recommended will give results. On poorer soils however or where manure is deficient the complete fertilizer is preferred. The amounts of nitrogen and potash depend on the soil. As a rule sandy soils need potash and all poor soils need nitrogen. Therefore a good grade of fertilizer containing all three elements will contain 2 or 3 per cent. nitrogen, 10 to 12 per cent. available phosphoric acid and 2 to 4 per cent. potash. If the soil contains plenty of potash such as a clay, a fertilizer analyzing 2-12-0 or 2-10-0 might be used. Fertilizers such as 2-8-2 or 2-10-2 have been used considerably, but should be discarded for higher analysis. It is more economical to use high analysis goods and if the amount of money to be expended is limited, it is better to apply a smaller quantity. The ideal method of applying fertilizer to corn as described before is the side lower plane position, which however is difficult to attain with the present distributing machinery.

FERTILIZING THE APPLE ORCHARD

Apple growers are all agreed that healthy vigorous trees are necessary to a successful crop. The tree's vigor can be determined with almost absolute certainty by the terminal growth each year. Nitrogen in a readily available form increases that growth, making the blossoms vigorous the foliage more resistant to disease and enables the tree to hold its leaves for a longer period.

This is altogether different treatment from what was prescribed ten years ago but agricultural investigations have proceeded rapidly in the last decade. At that time complete fertilizers were recommended, the nitrogen to produce stem growth, the phosphoric acid to form fruit and the potash to give good color. We now recognize the fact that the only value of phosphoric acid in an orchard is to encourage the growth of legumes used as cover crops to increase the nitrogen content of the soil. The potash fulfils largely the same purpose and as a result they are not used in modern orchard practice. The trees having a large feeding area and feeding as they do in the lower layers of the soil are not influenced greatly by the mineral elements applied on the surface.

The only requirement then is nitrogen and this should be in an easily available form. Nitrate of soda or calcium nitrate are instantly available, contain the same percentage of nitrogen and may be handled identically. Some experimenters claim that sulphate of ammonia is as effective and if so there is no reason why we should not use the newer nitrogenous materials, ammonium sulphate-nitrate and urea. These contain higher percentages of nitrogen however, and must be handled carefully. Experiments have been laid down this spring, 1926, by the Departments of Chemistry and Horticulture to compare these newer products with the old materials such as nitrate of soda. The general method of application is, of course, to distribute evenly as far out as the tips of the branches, starting three feet from the trunk. There are few feeding roots near the trunk of the apple.

The quantities of nitrate of soda or calcium nitrate are as follows:—

5 year trees	2 pounds
6-8 " "	2 to 3 pounds
9-12 " "	4 to 8 "
13-30 " "	8 pounds

This of course varies according to climatic conditions and cultural methods. It is generally conceded that the time of application should be between the delayed dormant spray and the bursting of the bud. The tree needs it at that time to make quick growth, to give strength to the fruit buds and to develop fruit spurs for the following season. These fruit spurs make their growth within a month's time of the bursting of the buds.

Recent investigations however indicate the possibility that fall application of nitrogen may prove as good as, if not superior to spring application. If this be so, it may influence the prevailing practice.

FERTILIZING TOMATOES

The chief reasons for unsatisfactory returns with this crop are low yields and poor quality. The interests of the grower and the operator of the canning factory in securing high yields and high quality are mutual. A high quality canned product cannot be made with poor tomatoes.

The average yield of tomatoes for canning purposes is about four tons to the acre. Such crops do not pay the expense of growing. Fair crops only give the grower low day wages. High yielding tomato crops are profitable. From ten to twenty-five tons per acre are often produced when proper methods are used.

Tomatoes will grow well on most soil types provided these are well drained and have good exposure to the sun. Soils containing plenty of organic matter will start tomato plants more quickly and maintain them better throughout the growing season. If the soil is deficient in organic matter this should be furnished in these days of diminishing manure supplies by growing cover crops and turning them under. It has been successfully demonstrated that tomatoes can be grown successfully by using cover crops and supplementing them with commercial fertilizers. The proper variety of course must be used as two varieties vary greatly in their yield. Strains of the same variety also show great differences. Large yields and high quality cannot be obtained from "leggy" plants. Tall slender crowded plants grown under conditions which are too moist and too warm are unsuited to field planting. The check they receive and the time taken in recovery often reduces the yield fully 50 per cent. Stocky plants which have been grown under good exposure at proper distances and properly hardened off, are the kind to use.

Nitrogen in the fertilizer produces leaf and stalk growth, which are vitally concerned with the yield. Too much nitrogen however, with a deficiency of phosphoric acid and potash may cause over stimulation and a consequent watery growth which usually makes the plant more susceptible to diseases. Phosphoric acid develops a better root system, tends to hasten ripening and gives strength to the plants.

Potash leads also to earlier ripening, improves the color, increases the size and weight of fruit, gives a firmer texture with less tendency to crack and helps to make a stronger better plant. Early and second varieties require more nitrogen stimulation while with late varieties the nitrogen may be reduced by one-tenth to one-fifth in amount.

A well balanced plant food ration containing the proper proportions of nitrogen, phosphoric acid and potash, which are furnished in complete fertilizers, grows more healthy plants, gives larger yields and makes finer fruit.

Assuming that fertilizer is to be applied 600 pounds per acre, three hundred may be applied before setting the plants out and the rest distributed about two weeks later. Beside this it is sometimes profitable to apply quickly available nitrogen, particularly on poor soils, along the sides of the rows during the planting season. The material generally used is nitrate of soda. Some prefer blood meal, but there is no reason why any other available nitrogen compound should not be used. The choice of fertilizer for tomatoes varies greatly. Where the soil is in good heart an 0-12-6 or 2-12-2 would prove satisfactory. This would also do with manure. If manure be not used a 4-8-6, 4-8-4 or 4-12-4 would be of value. On light sandy soils a 5-8-7 is used with good effect. There can be no definite recommendations for all cases. All a man can do is follow the general principles and attempt to prove what will give him the best results.

FERTILIZING THE POTATO CROP

The potato crop is an important crop in Ontario particularly in the southern counties and in the section around Fort William and Port Arthur. Although the two districts are widely separated, their fertilizer problems are somewhat similar. To illustrate, the southern sections grow potatoes for the early market, attempting to get them ready for sale by July. As a result early growth is required and the plant food supply must be plentiful and available. The phosphoric acid and potash is available in most fertilizers so the only thing left to consider is the nitrogen. This should be in an available form, which calls for nitrate of soda, calcium nitrate, or ammonium sulphate-nitrate. These are all rapid in action and are almost indispensable for early growth. In Northern Ontario the growing season is short and hence growth must be rapid from an early start. If fertilizers be used then the nitrogen contained in them must be quickly available.

It is quite possible, however, to keep up the supply of nitrogen in the soil by means of clovers, particularly sweet clover. Some of the most progressive potato growers follow a three year rotation of grain, sweet clover and potatoes. This is of course for main crop potatoes. The clover is ploughed under in May after it has attained some growth and the potatoes planted soon after. In this way a great deal of the nitrogen required by the potato crop is supplied by the clover, and under such conditions the nitrogen requirement in a fertilizer is greatly reduced and rarely is there an increase in yield when a fertilizer containing more than four per cent. is used at the rate of six hundred pounds per acre.

For early crop potatoes, however, it is better to plough the clover under the previous autumn and even when this is done it is preferable to use a fertilizer containing available nitrogen, but not above four per cent.

On the other hand the phosphoric acid content of potato fertilizers should be as high as possible, not below ten per cent. and preferably higher.

The potash content reaches its maximum effect on yields at about six per cent., hence the mixture known as a 4-8-10 is no longer recognized as a potato fertilizer except possibly on a soil very deficient in potash.

Five years' results of experimental work done by this department is summarized as a graph on page 49. The highest yields were obtained from fertilizers analyzing 0-10-6, 6-10-0, 3-10-3. It will be noted that the increase of potash and the decrease of phosphoric acid increases the yield up to six per cent. potash. The addition of nitrogen to phosphoric acid has an immediate effect on the yield up to six per cent. Nitrogen and potash together are useless as a potato fertilizer, so it can be easily seen that phosphoric acid is the limiting factor.

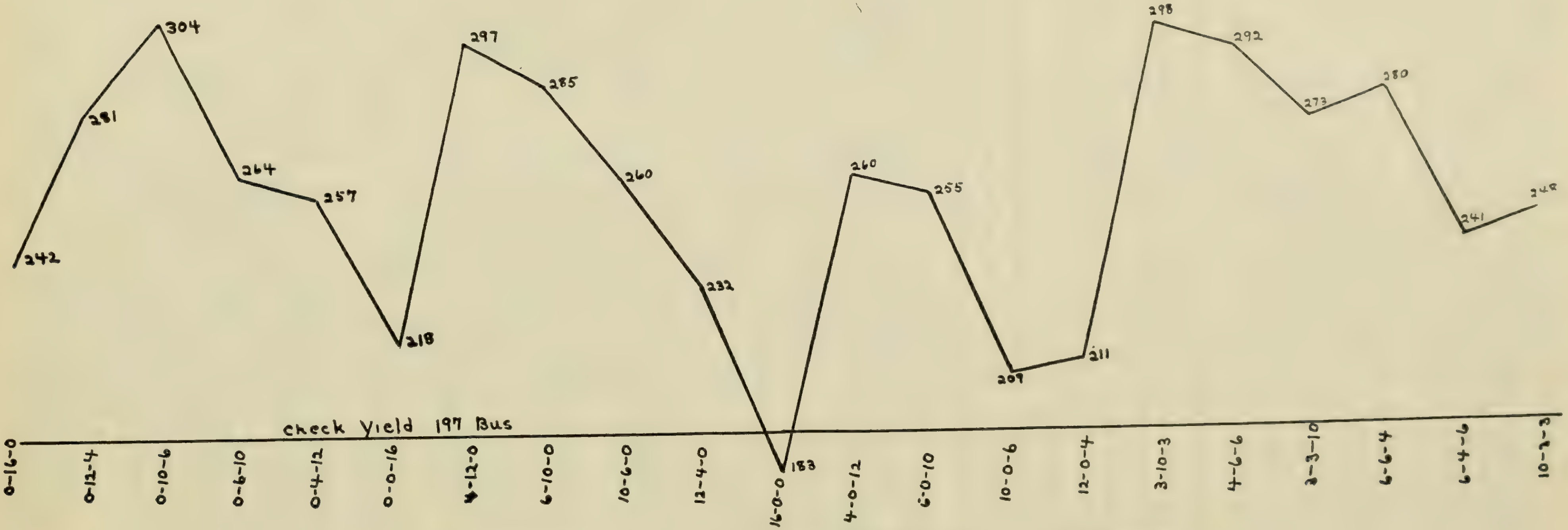
Perhaps a few points on the effect of fertilizer on disease of potatoes would be of interest. German results have shown that in experiments with stable manure and commercial fertilizers the leaf roll disease was found to be worse on unfertilized plots. It was also very serious on plots containing no potash and to a less extent on the plots containing no phosphoric acid, while on plots ertilized with stable manure and with a complete fertilizer containing nitrate of soda, potash and phosphoric acid the outbreak of the disease was checked. A strong growthy plant is always more resistant to disease than a weak one or one in which the growth is lush and soft. If fertilizers produce this type of growth they are to be desired.

The effect of each constituent on the tuber is rather interesting also. Recent work (1925) indicates that nitrogen increases the number of tubers per plant, but has no effect on the size of tubers. Potash generally increased the size of tubers, but had little or no effect on the number. It is also reported that phosphoric acid had no effect either way, but the authors of this bulletin know definitely that it is the limiting factor on many Ontario soils and should be in the greatest quantity.

FERTILIZERS FOR GOLF COURSE

On the golf course there exist two totally distinct fertilizer problems, that of fertilizing fairways and fertilizing greens. On the fairways the grass should present the surface to be expected in a well kept lawn. Clovers are in many cases present and according to some, very desirable. On a green however, a close even turf, springy in nature is desired, entirely free from coarse grass, weeds or clovers. This turf is mainly dependent on the type of grass grown, which necessitates soil conditions suitable for grass, but unsuitable for clovers and weeds.

This latter condition is brought about by using fertilizers which exert an acid effect on the soil, two of which, ammonium sulphate and ammonium



Summary of Five Years' Fertilization of Potatoes phosphate are the best. There have been attempts to make the soil acid before seeding but the most of them have proven impracticable.

Ammonium salts have three functions as follows:—

1. They are fertilizers especially supplying nitrogen.

2. Unlike all other nitrogenous fertilizers they make the soil progressively more acid. This is highly important because when the soil reaches a certain acidity, clover, chuckweed, crabgrass and other weeds will disappear and will not again invade the turf, providing the soil is kept properly acid. Lime bonemeal, etc. will counteract this desirable acidity and therefore should never be used on putting green, as if the acidity is counteracted weeds will again be troublesome.

3. With the continued use of either of these ammonium salts earth worms and grubs will cease to be troublesome.

The soil is properly acid when white clover disappears. Until this condition is secured the ammonium salt may be applied each week. The length of time will vary according to the alkaline reserve of the soil. If the soil is already neutral or slightly acid the end will be obtained in one season or less. If the original soil is alkaline a longer time will be required but with continuous composting eventually the top soil will become acid.

The most important part of care and maintenance of golf greens is top dressing. This is absolutely necessary and when properly done is the most important part of the work.

When it is Necessary to Topdress.—The results of experiments carried on in various places indicate that a very satisfactory method of applying topdressing is once a month during the growing season, which in Ontario is from about April 15 or May 1st until October 1st. Of course the frequency may be increased or decreased somewhat as may be rendered necessary by prevailing conditions without great variation in the results obtained. Many green keepers agree that the monthly method of application is very practical and satisfactory.

Materials for Topdressing.—For ordinary clay loam soil a compost made of equal parts of loam, sharp sand and well rotted stable manure or similar organic matter, has been found to give very good results. These proportions should be varied according to the type of soil on which the compost is to be used. If it is to be used on sandy soil, the percentage of sand should be decreased and the percentage of loam increased. If it is to be used on sandy soil the percentage of sand should be decreased and the percentage of loam increased. This compost dressing should be reinforced with ammonium sulphate or ammonium phosphate as these fertilizers tend to keep the grass in good condition.

Rate of Application.—One cubic yard of compost in which has been thoroughly mixed 10 to 25 pounds of ammonium sulphate or ammonium phosphate is sufficient to dress 5,000 square feet of green, after the turf has been established. In the early stages of a creeping bent green—before it is in a playable condition—it may be found necessary to make slightly heavier applications in order to get a smooth and firm surface more quickly. The amount of fertilizer should be varied according to the season. In the cooler months of spring and fall five pounds per 1,000 square feet of green or 25 pounds per cubic yard of compost may be used in the hot months of summer, however, the quantity should be reduced to about two pounds per 1,000 square feet, or 10 pounds per cubic yard of compost.

Some green keepers prefer to use the fertilizer alone without compost probably because no compost is available—but it is not good practice, and compost must be used in order to produce a really fine green.

Methods of Applying Compost.—There are two general methods of applying compost to greens. Each is satisfactory as far as results are concerned. Spreading compost with a shovel is a rather slow method, but if it is raked well after, an even distribution can be obtained. Machines are obtainable for the application of compost and they do the work very well indeed. At the time of application the compost should be well brushed down into the turf. It may be rubbed in with the back of a rake or may be brushed in with a flexible metal door mat, dragging it over the green. Some green keepers use ordinary chicken wire weighted down with boards and claim it does good work.

Why it is Necessary to Topdress Greens.—There are many reasons for topdressing greens. It is essential in the first case because topdressing supplied plant food necessary for the growth of turf grasses. It adds to the green a new surface of fresh soil which is essential to the healthy condition of the turf and which keeps the surface from becoming too hard. It fills up small depressions making the surface smooth and level. It is necessary in creeping bent greens because it keeps the turf which is continuously accumulating above the surface of the soil filled and firm. If creeping bent is allowed to grow through the season without topdressing a mat of loose, fluffy or spongy turf will develop, a condition about which many complaints have been received, On the other hand if the greens are topdressed as suggested and cut closely the turf will be firm and true, simply because the compost serves to fill in the open spaces that occur between the stolons and runners.

Fertilizers for Fairways.—Fertilizers for fairways may be varied considerably. Topdressing as previously described is very desirable, providing the compost can be obtained, in fact some clubs compost all their fairways. This is expensive of course and therefore the use of fertilizer is perhaps preferable. If clovers are desired then any good mixed fertilizer will give good results. Potash is not regarded by some as being essential but in our opinion it should be included. A good mixture then would be 5-12-0 where no potash is desired or a 3-10-3 where it is. Ordinary tankage analysis, 6-10-0 proves satisfactory as well at the rate of 400 pounds per acre.

If clovers are not desired and a pure grass fairway wished for, the ammonium sulphate or ammonium phosphate will give good results, applied at the rate of five pounds per 1,000 square feet. As it is liable to cause scorching of the grass, it must be watered in. This on a large fairway takes a great deal of work. One club has solved the difficulty however, in this way. When a continued rain is in prospect, the fertilizer drill is put to work covering it so as to keep the fertilizer dry and allowing the rain to wash it in. This is possibly the best method of application although the times of application may be very variable. By taking advantage of every opportunity, however, this club keeps its fairways in excellent shape, even though the application has not been carried on long enough to get rid of weeds and clovers.

Effect of Acidity on Weed Growth.—Considerable experimental work has been done at Arlington Turf gardens on the effect of different fertilizers on soil acidity and weed growth. The results are given in the following table. It may be noticed that where the soil is quite acid in nature weed growth is at a minimum and the bent grass reaches its greatest maximum. Where the soil is alkaline, however, weeds are very prevalent and bent does not do so well. Since bent grasses are the best for golf green work, and an acid condition is preferable for their best development the following table is given:

EFFECT OF VARIOUS FERTILIZERS ON PH VALUES AND PLANT GROWTH IN PLOTS OF RHODE ISLAND BENT AT ARLINGTON TURF GARDEN, VIRGINIA.

Fertilizer	P H	% of weeds	Kind of weeds
Amm. sulph	3.7	12%	Crab grass (good stand of bent).
Amm. phosphate	4.6	15%	Crab grass (good stand of bent).
Amm. sulphate, bone meal, KC1	4.1	20%	Crab grass.
Amm. sulph., acid phos.	3.7	20%	Crab grass (good stand of bent).
Amm. sulphate, bone meal	3.8	25%	Crab grass.
Cotton seed meal	4.8	30%	Crab grass, a little yarrow.
Check plot	4.6	45%	31% crab grass, 9% spurrey, 3% yarrow, 2% plantain and others. Thin and poor stand of bent.
Bone meal	4.9	50%	22½% crab grass, 22½% yarrow, 2½% clover, 2½% plantain.
Soybean meal	4.6	60 %	52% crab grass, 6% yarrow, 2% chickweed, and others
Sodium nitrate	6.3	80%	72% crab grass, 4% silver crab grass, 4% yarrow.
Acid phos., sodium nitrate and KC. mixed	5.8	80%	56% crab grass, 4% silver crab grass, 4% yarrow, 16% miscellaneous.
Manure	5.1	85%	51% ordinary crab grass, 9% yarrow, 4% plantain, 21% dock dandelion, chickweed, ranunculus, white clover, cinquefoil, sorrel, and others.
Ground limestone	....	85%	68% ordinary crab grass, 4% yarrow, 4% clover, 9% dandelions, plantain and others (weak stand of bent).

FERTILIZING THE HOME GARDEN

During the year many enquiries are received at this department as to fertilizing vegetable and flower gardens. In response to these enquiries the following will probably prove of value.

The first thing to consider in a garden is the soil. It is plainly unadvisable to attempt to make a garden on the soil which is thrown out in excavating a cellar. In purchased houses it is impossible to control this factor, but if one is building and planning for a future garden or lawn all the top soil should be carefully piled on one side to cover the subsoil later removed. But even if considerable subsoil is present it is possible to build up a fair garden in time.

The first requisite for a successful garden is plenty of organic matter and this is best supplied by ordinary stable manure applied as heavily as circumstances will permit—the heavier the application the better. It is the best fertilizer obtainable. It should be dug in fairly deeply, trenching if necessary and thoroughly mixed with the soil. It is better dug in, in the fall rather than in the spring and should not come in direct contact with the roots or bulbs of established plants. The latter, of course, applied particularly to perennial borders. If plenty of manure is supplied, whether to vegetables or flowers, the only additional material required will be some carrier of phosphoric acid and possibly one carrying quickly available nitrogen. The purpose in supplying plenty of phosphoric acid as to hasten maturity and to stimulate flowering. The purpose of the nitrogen is to force early growth.

The best source of phosphoric acid for this purpose is probably bone meal. It is slow in action, but absolutely safe to use. For the inexperienced user of fertilizer materials it is therefore very desirable since no harm can be done to the plants by its use. The chief difficulty with the soluble fertilizer materials is that they are concentrated and if too heavy an application is made, plasmolysis will occur—or as the average man says the fertilizer will "burn the roots." Many people consider if a little is good, a good application is better, which is a serious mistake. *Inexperienced* users of fertilizers should remember that many of the materials already described *must be used very carefully*, in order *to avoid injury* to plants.

On no consideration should any soluble materials come in contact with the foliage when wet, and care should be taken to see that none remains on the leaf if applied when the plants are dry. It has been reported that potash intensifies colour in flowers, but this has not been substantiated. At the same time, if a mixed fertilizer be used it would be as well to include potash.

After manuring and digging, bone meal may be applied in almost any quantity—a double handful per square yard works well and raked or hoed in. This is an excellent fertilizer for all shrubs, perennials, roses, etc. There is enough nitrogen supplied to produce good stem growth and the phosphoric acid stimulates flowering.

If additional forcing of early growth is desirable, then nitrate of soda should be used in early spring, after growth starts at the rate of a tablespoonful per gallon of water, applied with a watering can, after the regular watering. This may be repeated twice about ten days apart.

Or the nitrate may be applied dry alongside the rows, a few inches from them and worked in. A pound will be sufficient for fifty feet of row. Nitrate of soda should be used sparingly on flowers as it tends to make plants produce too much stem and leaf growth.

The use of a complete fertilizer, 4-8-4, is justified if manure is scarce, and the directions are on the package generally. The fertilizer having this analysis is sold in five-pound packages for garden use, and when used according to directions proves to give excellent satisfaction.

It is impossible in this bulletin to give complete detailed directions for fertilizing each type of shrub and flowering plant. Therefore anyone requiring special information should write to the Department of Chemistry or Department of Horticulture, O.A.C., Guelph.

SOIL AMENDMENTS

The term "soil amendment" is applied to all materials which are not applied to the soil for the purpose of supplying nitrogen phosphoric acid or potash. This would include all forms of lime, gypsum or land plaster, salt sulphur and other substances.

The action of these substances in the soil is largely indirect as they do not generally supply any deficiency in plant food elements. The action may be exerted in two ways: (1) by liberation of essential plant food elements from the soil, (2) by altering the soil reaction. By the latter is meant changing the degree of acidity or alkalinity of the soil. In view of the fact that a great deal of these materials is used in Ontario, probably a short discussion of each will be of interest.

LIME.—Lime in its several forms acts as a neutralizer of soil acidity and also liberates some plant food, mainly potash, from the soil. A complete discussion of this important soil amendment is given in Bull. 313, Soil Acidity and Liming.

Gypsum.—This material is of great value as a corrective for alkali conditions changing the sodium carbonate (black alkali) into the sulphate, thereby reducing its harmful effect. It has been used extensively in this Province but is not used to such an extent now. As a corrective for soil acidity it is useless, but is of value particularly to legumes on account of its calcium and sulphur content. If acid phosphate or fertilizers containing it are used, there is no object in purchasing gypsum, because acid phosphate contains a great deal of it.

Salt.—Salt contains only two elements, sodium and chlorine, neither of which are ever deficient in soils. It is therefore of no direct value to plants, but has some beneficial effect by releasing potash, calcium and magnesium from the soil. Its use is not recommended.

Sulphur.—Sulphur has been used to a considerable extent in United States and to a less extent in Ontario. It is applied as ordinary flour of sulphur, from 100 to 500 pounds per acre. Its action in the soil tends always to increase acidity, which in many cases is beneficial and desirable. This is particularly true with respect to potatoes, where a moderate degree of acidity tends to prevent potato scab. It is also beneficial when the sulphur is applied with rock phosphate, the acid formed combining with the rock phosphate rendering the phosphoric acid available. Experiments are being carried on by the Department of Chemistry to determine the value of sulphur on Ontario soils, but results are not as yet conclusive.

In consideration of the fact that the rainfall deposits annually considerable sulphur on the soil and that the demand of plant growth is small, the use of sulphur is not generally recommended. Further, all our mixed fertilizers contain sulphur in combination and, therefore, where they are used, sulphur is supplied in sufficient quantities to supply all requirements.

There are other materials which, when added to the soil, give increased crop returns, but they are not generally used and are not recommended. Fertilizer practice should be confined to materials containing the three essential elements—nitrogen, phosphoric acid and potash.

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Ontario Department of Agriculture

HORTICULTURAL EXPERIMENTAL STATION
VINELAND STATION, ONTARIO

THE APPLE IN ONTARIO

INTRODUCTION

"The origin of the cultivated apple is unknown. It is supposed, however, that it had its beginning in the wild apple of Europe (Pyrus Malus), but there is no evidence to show when the improvement began, nor when the fruit reached the size, colour and quality of what is considered a good apple to-day. It is known, however, that at the beginning of the Christian era, the Romans cultivated a few varieties of apple which might compare favourably with some that are grown at the present time. Although the apple is mentioned in Holy Scripture many years prior to that period, the word evidently referred to another fruit, or fruits, and not to what is now called an apple."*

The Romans carried the apple to England and from thence it spread to the New World. In Canada it was probably planted first in what is now the Province of Quebec early in the 17th century. The exact date is not known.

EXTENT OF THE APPLE INDUSTRY

The apple is the most important fruit grown in Ontario. This is shown by the number of trees planted and also by the value of the fruit produced. According to the census of 1921 there were 4,492,672 bearing trees and 987,115 non-bearing trees in Ontario, or a total of 5,479,787. The bearing trees yielded 9,187,703 bushels valued at $6,194,254, a sum more than twice that of all other tree fruits combined, and three-fourths that of the combined production of all kinds of fruit other than apples.

The following table taken from the census report for 1921 shows the number and distribution of apple trees in Ontario:

NUMBER OF APPLE TREES IN ONTARIO—CENSUS REPORT 1921

County	Bearing	Nonbearing	County	Bearing	Nonbearing
Algoma	8,867	4,427	Frontenac	29,331	7,696
Brant	79,963	10,871	Glengarry	18,312	7,250
Bruce	166,017	8,947	Grenville	33,805	14,273
Carlton	32,661	19,898	Grey	266,607	28,295
Dufferin	36,764	3,638	Haldimand	91,177	4,716
Dundas	30,670	14,207	Haliburton	1,807	792
Durham	186,997	62,542	Halton	125,882	35,597
Elgin	126,559	18,079	Hastings	115,703	18,503
Essex	71,078	24,212	Huron	276,912	27,930

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*W. T. Macoun, The Apple in Canada.

County	Bearing	Nonbearing
Kenora	......	79
Kent	89,176	16,595
Lambton	207,006	34,164
Lanark	17,764	6,254
Leeds	28,986	6,313
Lennox and Addington	44,638	3,389
Lincoln	98,895	24,310
Manitoulin	5,019	2,493
Middlesex	222,289	17,934
Muskoka	1,453	819
Nipissing	347	613
Norfolk	138,042	121,890
Northumberland	344,843	90,690
Ontario	130,423	79,953
Oxford	140,207	23,044
Parry Sound	913	1,436
Peel	101,064	42,562
Perth	116,286	8,404
Peterboro	37,041	7,905
Prescott	4,596	3,180
Prince Edward	235,322	27,530
Rainy River	1	23
Renfrew	10,426	7,541
Russell	7,193	4,990
Simcoe	163,846	25,300
Stormont	22,078	6,897
Sudbury	42	149
Thunder Bay	116	61
Timiskaming	3	84
Victoria	33,821	8,384
Waterloo	92,055	12,176
Welland	99,707	9,542
Wellington	101,228	9,824
Wentworth	146,113	27,798
York	152,621	42,016

These figures indicate widespread apple plantings over the Province. Commercial production, however, is centered largely in several fairly well-defined areas. The more important of these are as follows:

1. *The Georgian Bay District*—Simcoe and Grey Counties. Collingwood, Meaford, Thornbury and Clarksburg are some of the well-known producing centres in these counties.

2. *Lake Huron Counties.*—Those parts of the Counties of Bruce, Huron and Lambton which border on the east shore of Lake Huron produce large quantities of apples. Goderich and Clinton in Huron County, and Thedford and Forest in Lambton are some of the better known areas.

3. *Lake Erie Counties.*—Apples are grown in large quantities in all the counties bordering on Lake Erie. Norfolk County leads, particularly in young orchards, and included in this district are also Essex, Kent, Haldimand and Welland.

4. *The Niagara District and Neighbouring Counties* of Wentworth, Halton and Peel grouped around the head of Lake Ontario. Ancaster, Burlington and Oakville have long been known for their apple production.

5. *North Shore of Lake Ontario.*—In the District between Toronto and Belleville is situated probably the largest apple producing area in the Province. In number of bearing trees, Nortumberland County leads other counties of the Province by a considerable margin. Other heavy producing counties in the Lake Ontario District are York, Ontario, Durham, Prince Edward and Hastings. The bulk of Ontario's export apples are grown in this district, Bowmanville, Oshawa, Newcastle, Port Hope, Cobourg, Brighton and Trenton being among the large shipping points. The main plantings in this District are within a short distance of the Lake.

6. *St. Lawrence River Area.*—Considerable quantities of apples, especially of the hardier varieties, are grown in this district.

7. A District hard to define, but which annually produces a considerable portion of Ontario's total crop, is comprised in those *inland counties of Southern Ontario* included in the following group: Brant, Oxford, Middlesex, Perth, Waterloo and Wellington.

Except in the more northerly districts all the commercially recommended varieties are grown to a greater or less extent in the various districts noted.

Certain districts, however, have certain preferences. The Georgian Bay district is noted for its Northern Spies. Essex is able to grow well such varieties as Jonathan, Winesap and Grimes, while Norfolk produces largely Baldwin, Fameuse, Scarlet Pippin, etc. East of Toronto export varieties such as Stark, Ben Davis, Golden Russet, etc., have had the preference in the past. Throughout the whole of the Province the McIntosh Red holds a favoured place, though reaching highest quality and perfection in the more northerly apple districts such as the St. Lawrence River region.

SELECTION OF VARIETIES

In selecting varieties there are several things to be taken into consideration. First, the adaptability of a variety to a section in regard to hardiness, productiveness and the degree of development which the fruit attains before the close of the season. For instance, it is questionable if the Baldwin should be planted east of Toronto, as the tree has proved tender in so many cases. Again, the Spy in many seasons will not attain full size or colour in some of our counties. Second, the markets to which it is intended to cater, whether Great Britain, Europe, United States or our home market. The British market is more or less stable as far as demand and prices are concerned, but the altering of the tariff by European countries or the United States would affect the trade considerably. As a general thing, however, all out markets will take the same varieties. Third, the number of varieties to plant and ratio of each. Do not plant a greater number of varieties than is absolutely necessary to take care of your markets. Too many varieties are a nuisance. They are harder to market and many phases of the work are not so economically performed as when the orchard has fewer varieties. Plant your varieties in blocks so they may be pruned, sprayed and harvested with as little extra labour as possible. The only exception to this statement is that it is advisable to plant more than one variety in an orchard so as to get a sufficient fertilization of the bloom to ensure a good crop in all varieties, but more particularly in those kinds like the Spy, which may be more or less self-sterile.

POLLINATION AND FRUIT SETTING

The above brings up a matter often referred to but of which very little is known definitely in this province, the question of pollination of varieties. Is it safe to set out large blocks of Spy without other varieties to provide pollen that will ensure liberal setting of fruit?

Chandler, in his recently published book, "Fruit Growing," brings together in tabular form all of the published work on pollination. Chandler states as follows: "The results of the different workers suggest that in a good many climates, Baldwin, Green Newtown, Grimes Golden, Ingram, Keswick, Oldenburg, Wealthy, and Yellow Transparent tend to be self-fruitful to a satisfactory degree. This may not mean that the flowers are more highly self-compatible than those of some other varieties. It may mean only that fruit will set with a smaller number of seed or with no seed. Thus, in years when the weather at blooming time is unfavourable for pollination, Oldenburg generally sets a good crop; but the average number of seed to the fruit will be smaller than the number in years when the weather at blooming time is favourable. In the Cornell University orchard in 1920 the average number of seeds to the fruit in 449 Oldenburg apples was 6.7; in 1921 the average number was 5.0, 1,200 fruits being examined; while in 1922 it was 6.69, 1,326 apples being examined. In the springs of 1920 and 1922 the weather at blooming time was more favourable for the setting of fruit than was that of 1921.

The evidence of the table suggests that Ben Davis, Cox Orange, Early Harvest, Esopus, Gano, Gravenstein, Jonathan, Red Astrachan, Red June, Ribston, Rome Beauty, Tompkins King and Wagener are self-compatible to a lower degree than are the varieties in the first group mentioned; that Fameuse, McIntosh, Northern Spy, Rhode Island Greening, Twenty Ounce, Winesap, Winter Banana and York Imperial are self-compatible only to a very slight extent, and that Arkansas, Arkansas Black, Lawver, Ralls, Shockley, Stark, Stayman, and Williams may be completely, or almost completely, self-unfruitful. With the greater percentage of the varieties studied, however, the evidence is far from being conclusive even for one set of climatic conditions."

In planting for cross-pollination it is not necessary to intermingle a large number of varieties. As a rule it is only necessary to plant a few varieties that blossom at about the same time and have these varieties in blocks of four to five rows each.

Macoun, in Experimental Farms Bulletin No. 86, "The Apple in Ontario," places apples in groups with reference to their blooming season. These groups are designated as early, medium and late. Amongst those of importance in the early group are Fameuse, Gravenstein, Duchess of Oldenburg, Wagener, and Scarlet Pippin. The medium group contains a large number of varieties and includes good commercial kinds such as King, McIntosh, Rhode Island Greening, Newtown Pippin, Rome Beauty, Jonathan, Golden Russet, Hubbardston, and Wealthy. The late group is much smaller and includes varieties such as Spy, Tolman, Grimes, Cranberry Pippin, and a few others of lesser importance.

The grouping as given above would in most cases produce satisfactory results in pollination, but here as in many other things there are exceptions. For example the McIntosh is not a good pollinator for the Greening, although the Greening seems to be satisfactory for the McIntosh. This statement is based on a limited amount of work done at the Horticultural Experiment Station during the season of 1922 and 1923. There are undoubtedly other cases of inter-sterility besides the above mentioned one.

RECOMMENDED VARIETIES

Owing to changes in market requirements and the introduction of new kinds that have attained popularity very quickly, some of our earlier standard varieties of lower quality are no longer in demand on our markets and prices offered are now generally below cost of production.

On this account, the following lists of varieties vary somewhat from those recommended fifteen to twenty years ago:

Melba.—An early variety of the Duchess season, a seedling of McIntosh originated at the C.E.F., Ottawa, hardy, with better flavour and keeping qualities than Duchess, good for all parts of the Province.

Fameuse.—Hardy all over the Province. Two types are grown, the striped of softer texture and better quality, and the red which is much firmer and a better keeper and seller.

McIntosh.—Hardy and of very fine flavour. At the present time, the most popular variety in our Canadian markets.

Delicious.—Tree considered hardy in most parts of the Province. One of the newer varieties of promise which has now fruited successfully as far east as Belleville.

Greening.—One of the best commercial varieties in all markets. Found hardy as far east as Belleville. Considered most promising in the southern counties.

Golden Russet.—A variety recommended largely on account of its favour on the export markets. Seems to do best in the section from Newcastle to Trenton, and parts of Huron County.

Spy.—Still the best winter variety for this Province and in strong demand in our Canadian markets.

The following varieties are well known and considerably planted in Ontario, but are not recommended for extensive planting without consideration of market conditions.

Astrachan.—The first early red variety, good only for local markets and in limited quantities, may be soon superceded by an early McIntosh seedling from the C.E.F., Ottawa.

Duchess.—Our earliest good cooking apple, but over-planted for present market requirements, and likely to be succeeded by the Melba.

Wealthy.—One of the best early dessert varieties, has been recommended as a filler on account of its early bearing and small tree. Planted in sufficient quantities to supply the markets for the present time.

Wolf River.—This variety with Alexander fills a market for a large baking apple in the fall, but the demand for this type being limited, it should not be planted very extensively.

Scarlet Pippin.—A high class dessert variety, quite popular in Norfolk County, but hardy as far east as Brockville. Not sufficiently known in the markets to be recommended for other than local trade.

Jonathan.—An old variety that has been extensively planted on the Western coast and is in favour on most markets for its high colour and quality. A few extensive plantings are now bearing in Ontario and suggest its consideration for at least the southern counties, providing it does not show the pitting or breakdown common in the west.

King.—This good apple has been condemned on its behaviour in our old farm orchards, showing weak trees and light crops. Considerable improvement in both tree and bearing habits is showing in the younger orchards and it is possible that this variety may be found profitable through the south where the tree is hardy.

Tolman.—This well-known variety is gaining popularity as a sweet baking apple and may be planted in limited quantities for local markets. It is not wanted for our export markets.

Wagner.—A good winter variety that has been recommended as a filler on account of its early bearing and small tree. The weakness of the tree makes it suitable only for this purpose.

Baldwin.—Very heavily planted in all parts of Ontario. Has not proven hardy in the eastern and northern counties and is sufficiently planted in the southern counties to supply the demand. This has been one of our standard varieties but is losing in popularity.

SELECTION OF SITE

If one is buying a farm in order to plant an apple orchard, he should of course exercise his judgment so as to secure the best shipping facilities. Then, in choosing a site for an orchard, choose the very best field on the farm. The apple crop, under proper management, will give profits much above any field crop grown, and therefore the orchard deserves the best treatment possible in the selection of soil.

Under the general term of site, the factors usually considered are: soil, elevation, and exposure. All of these exert some effect on the crop and therefore should be given consideration.

SOIL

It is frequently stated that the apple will grow on many soil types. This is of course quite true, but it is also an accepted fact that certain soils are better adapted for apples than others.

The ideal soil for apples seems to be a deep well-drained sandy loam or a light clay loam, with good moisture holding capacity and a moderately pervious subsoil.

The condition of soil with reference to depth of top soil, porosity, nature of subsoil, soil drainage and moisture holding capacity are factors of importance. Very heavy damp clays or coarse leachy soils generally are not satisfactory. The former are not suitable because of difficulty in working, while the latter are harder to maintain in a fertile condition and may lack moisture holding capacity.

For best results the surface and subsoil should have a depth of five or six feet. Where the rock surface or an impervious hardpan are within a short distance of the top the results are likely to be unsatisfactory. This of course does not hold good in every case, as there are certain conditions which may favour good returns under apparently adverse circumstances.

The ideal soil type previously described is usually fertile, or if not fertile it may be restored to the proper degree of fertility with greater ease than some of the less favoured soils. In years gone by and even in more recent times, trees were planted on poor soils. This was a mistake, as orchards so planted were necessarily comparatively unprofitable. Like any other tree fruit, apple trees can be more economically grown on fertile soils. This does not mean that apple trees will not grow on all soils that are commonly considered poor, as it has been shown that certain so-called poor soils will give good results if properly managed.

In such cases there are features such as favourable subsoil that may offset the apparent lack of fertility in the surface soil.

Soil drainage is also an important factor in relation to tree growth and productiveness. It has been amply demonstrated that poorly drained soils are unsuited to the apple or in fact to most other fruits. Fruit trees require a good range for root development and this desirable condition does not obtain on poorly drained soils. On such soils the root system is likely to be small and near the surface and thus may be more susceptible to drouth in summer or frost injury in winter. In this respect it has been observed that root killing, collar rot, and bark splitting are always worse on soils lacking in drainage. Wet soils do not warm up in the spring as quickly as well drained soils, and thus growth early in the season is retarded. Late autumn growth, which is undesirable, is also more likely to occur on wet soils because of the supply of excess moisture at a season when it is not needed. For the most permanent and profitable results the soil for apples and other tree fruits as well should be deeply and thoroughly drained by natural or artificial means.

ELEVATION

The experience of growers and the observation of those who have made a close study of the principles underlying fruit growing indicate that a site having some elevation above adjacent areas is preferable for apples. This is due to the fact that the trees on elevated areas are less likely to be damaged by late spring frosts than are trees on the lower levels. Cold air settles to the lower places and thus the temperature in a hollow, especially where pockets occur, will be lower than on the higher slopes near by. In some cases this difference amounts to several degrees thus accounting for frost injury in low places while the higher areas escape.

In some parts of this province there is a gradual slope toward one or the other of the Great Lakes and then a sudden drop to the water itself. Good examples of this are seen in the Niagara District on the south shore of Lake Ontario, and in the counties along the north shore of the same lake. Similar conditions exist also in the counties along Lake Erie and Lake Huron, particularly on Georgian Bay. This gives good air drainage and also favours soil drainage, factors that help to make these areas well adapted to apple culture. This should not be taken to mean that all the land in these areas is suited to apple culture. Such is not the case. However, the general topographical features of these regions provide many good orchard sites.

Good air drainage is also a factor in helping to control some of the diseases such as apple scale and sooty blotch, which attack the fruit and foliage. These diseases are always worse and are proportionately more difficult to control where there is a poor circulation of air such as is often found on sites of low elevation. For the most efficient results in spraying as well as for frost protection there should be good air drainage. This desirable condition is always found on sites which are elevated above the surrounding areas.

SLOPE

A site with a gentle slope is better adapted to tree fruits than one that is flat. This is because of the better air and soil drainage, the importance of which has been noted, rather than to the effect of any particular slope on the growth of the tree. The direction of the slope is not quite so important as the slope itself, but it is believed that a northern slope is best. If a northern slope has any merit over any other slope it is probably due to the greater immunity to sun scald which certain varieties show in contrast to the amount of sun scald on the same varieties grown on southern slopes. It is also probable that the soil on northern slopes is less subject to drouth than on southern slopes. On the other hand early varieties are likely to be somewhat later in ripening on northern slopes. In most parts of Ontario where apples are grown commercially, good results are secured from trees growing on sites some of which slope in one direction, some in another, so that it is just possible that this factor has been over-emphasized in the past. As previously stated it is more important to have a slope of some kind than that this slope should be in any special direction.

WINDBREAKS

Much has been said about windbreaks. Nearly every farmer appreciates the fact that a row of trees around the farm is a beautiful asset, and one which is no doubt a material advantage, but to plant a windbreak especially for an apple orchard is now seldom considered, particularly in the commercial apple sections of Ontario. The trees, when they have obtained their growth, act more or less as a windbreak for themselves. It is only during the first three or four years that the young trees will suffer any bad effects by the action of the wind in turning over the trees. This can be obviated by discontinuing the ill-advised practice of planting the largest trees obtainable regardless of age. The care taken in planting the young trees also exerts considerable influence in off-setting the action of the wind. This will be discussed under the heading of planting.

For those growers who desire a windbreak certain precautions in planting should be observed. The trees, usually evergreens, should not be set closely in the row so as to form a dense wall otherwise a still air space may be created which under certain conditions would be worse than no windbreak at all. It is also advisable to set the windbreak at least 40 feet from the apple trees to prevent competition with the nearest row of trees. The chief benefit of a windbreak appears to be in checking the force of the wind rather than in diverting it upward.

PLANTING

Preparation of Soil

Experience has shown that newly planted apple trees will start into growth earlier and generally do much better where the soil is fertile and in good physical condition. To attain this ideal it may be necessary to begin the preparation of the soil at least one year and perhaps two years before the trees are to be planted. An economical and satisfactory method of soil preparation is to grow a hoe crop such as corn, potatoes, beans, tomatoes, etc., during the season preceding the planting of the trees. In cases where the land has been in heavy sod for some time or where it is badly infested with weeds it would probably be advisable to grow the preparatory crops for two seasons before planting. The soil for these preparatory crops should be thoroughly enriched by heavy applications of stable manure where this desirable fertilizer can be easily obtained. Where stable manure is scarce, green crops such as red clover, sweet clover, vetch or other suitable crops should be plowed under as a substitute. An application of stable manure or green crops, or both where possible, will not only supply the preparatory crops with the necessary plant food, but will leave the soil in good physical condition for subsequent crops. After the final preparatory crop has been removed the land should be plowed and thoroughly worked down by the disc and harrows before planting the trees.

Planting Plans

There are several plans for setting out an orchard. These are known as the square, hexagonal, alternate and quincunx. The usual method is the square, whereby the trees are planted the same distance apart each way, four trees forming a square. By this method there is more room between the rows for the growing of other crops. The hexagonal plan gives the greatest number of trees per acre and divides the air and soil space more evenly. The alternate system sometimes used has no particular advantage except that diagonally the trees are farther apart. The disadvantage is that on a given rectangular area fewer trees can be planted, every other row lacking one tree (see figure). The quincunx sustem is the same as the square, except that a tree is planted in the centre of each square. This system is used more often for the planting of fillers in the centres of the squares. The square plan is the most common. It might be more correct to call it the rectangular system from the fact that many planters set their trees farther apart one way than the other.

NUMBER OF TREES PER ACRE PLANTED UNDER TWO SYSTEMS OF PLANTING

Distance apart each way.	Number of trees.	
	Rectangular.	Hexagonal.
20 feet	108	124
25 "	70	80
32 "	48	55
33 "	40	46
35 "	35	40
40 "	27	31

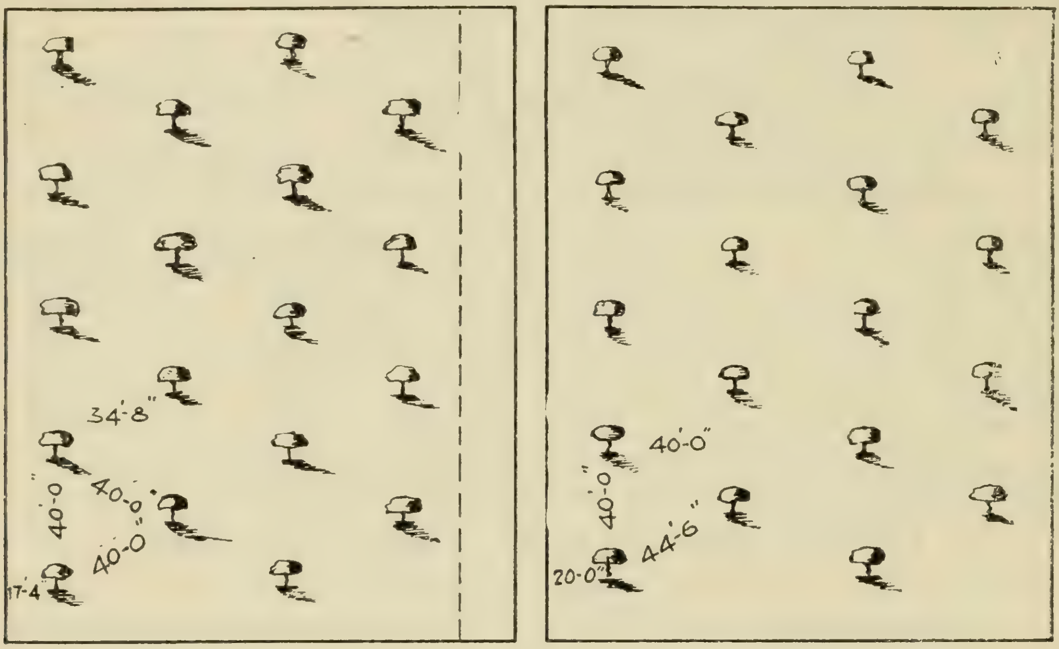
DISTANCE BETWEEN ROWS IN HEXAGONAL PLAN

Distance between trees.	Approximate distance between rows.
20 feet	17 feet 4 inches.
25 "	21 " 8 "
30 "	26 "
33 "	28 " 7 "
35 "	30 " 4
40 "	34 " 8 "

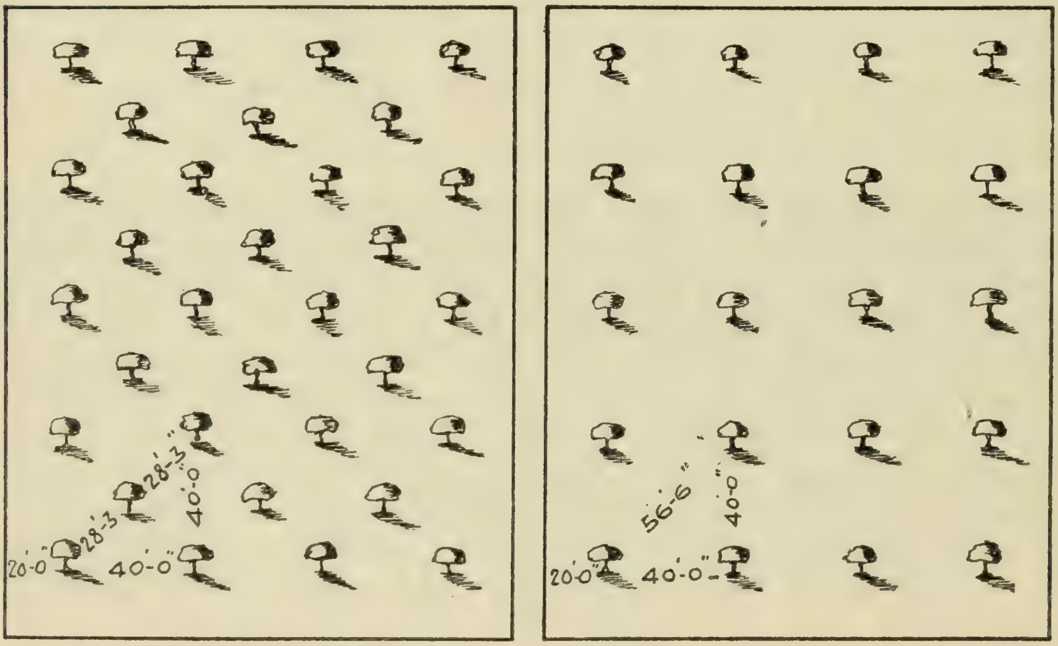
If the square plan is adopted, a base line should be located at one end of the field and the pegs put in at the desired distance. If the field is not too large, it would be well to stake out a line at the other end also. A wire may then be stretched between these two lines to find the positions for the trees. Secure a No. 10 gauge galvanized iron wire and solder or otherwise fasten washers to this wire at same distance apart as the trees are to stand in the row; then, with a man on each side, dig the hole under the washer, leaning the trunk of the tree against it. Some growers prefer to place stakes at each point on the wire, and having marked out the field afterwards use the planting board when setting the trees. Be sure to have the base lines correct, and to make the wire lie evenly and as straight as possible. If this is done, very little trouble will be experienced in getting good lines.

In staking out for the hexagonal plan, after the first row has been staked at the desired distance, the position of trees in the second row, and also the distance apart of that and the following rows, may easily be ascertained by taking two pieces of wire, fasten one end of each wire to a 2½-inch iron ring and to each of the two loose ends fasten another ring. When stretched out these rings should measure from centre to centre the same distance that your trees are to be planted apart. Then by placing one ring over the first stake and another over the second stake and pulling the wires taught and placing a stake through the third ring you will have the position of the first tree in the second row. By changing the rings to second and third stakes the position of the second tree is located, and so on until the entire orchard is planted.

The field should be partly or wholly staked before planting is commenced. If this is done, it will be found a much easier matter to get the lines straight. Some orchardists do not take the trouble to line out their trees in exact and



HEXAGONAL ALTERNATE



QUINCUNX SQUARE

Planting systems for the apple orchard.

straight lines. This is to be regretted, however, for as crooked lines in plowing are unmistakable signs of slipshod farming, crooked lines in an orchard are still more unmistakable signs of rather a careless fruit grower. A planting board is necessary in order to get the trees in the exact position of the stakes. This board is inexpensive and easily made.

DISTANCE APART TO PLANT

The distance apart must be determined wholly by the final development of the variety. Soil, climate and pruning all bear some relation to it, but to the general orchardist this relation is so small that it is unnecessary to take these points into consideration. The question to ask oneself in deciding the distance is: "What is the habit of growth of the variety or varieties that I want to grow?" and "How large do the trees get when they reach maturity?" Give a tree plenty of room; it will always utilize it; but at the same time be ecomonical with your ground. Forty feet both ways is not too much for our strong-growing standards in the best apple districts. Even in the northern and extreme eastern sections thirty-five feet should be allowed.

The following varieties might be taken as strong-growing varieties in the better apple sections: Astrachan, Baldwin, Cranberry, Fameuse, Golden Russet, Gravenstein, Greening, King, McIntosh, and Spy. Trees of more medium growth are: Alexander, Ben Davis, Blenheim, Hubbardston, Ribston, and Stark, while the following are smaller in habit of growth: Dutchess, Wagener, Wealthy and the various varieties of crab apples.

USE OF FILLERS

A great many discussions have taken place on the question of interplanting in order to utilize space and procure a paying crop of fruit from early-maturing varieties while the late-maturing or standard varieties are developing. There is a question now whether interplanting is the most profitable and proper thing to do. One great objection to interplanting with fillers is that the grower, in many cases, does not remove the fillers until they have done much damage, and in most cases this neglect is due to the fruit grower's disinclination to remove these trees before they have produced a profitable crop. The grower ought to perceive that his object is to produce a profitable permanent orchard.

There are two methods of interplanting: One being with varieties of tender fruits, such as peaches, pears, plums, cherries, and small fruits; the other with early-maturing and small growing varieties of apples. Generally speaking it is better to interplant apples with apples, or with small fruits, etc. When interplanted with peaches or other tree fruits, the spraying programme and also other orchard operations become very involved and unnecessarily expensive.

Interplanting is not desirable unless the distance is 40 x 40 for the permanent trees, in which case the fillers should be planted one way between the permanent trees, leaving the trees 20 x 40 or in the centre of the square formed by the permanent trees, which would be the quincunx plan with the trees 40 x 28.3.

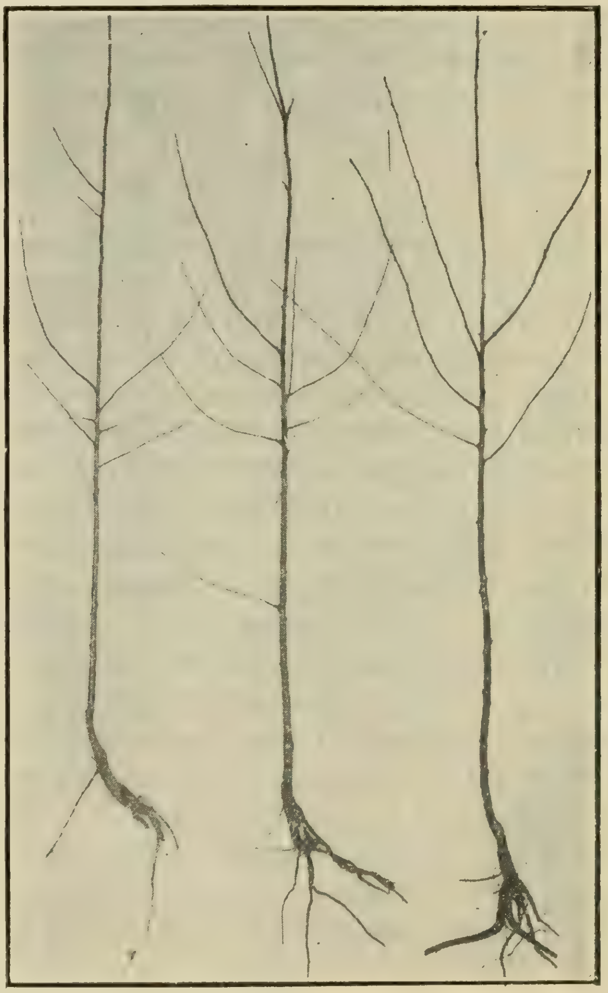
ORDERING TREES

Having decided upon the varieties it is intended to plant and the quantity necessary, the next step is to order the best trees possible. To do this it is advisable to write direct to the nurseryman, sending the list and number of each variety, describing the kind of stock required, and asking for prices. This should be done as early as possible. Do not wait until the spring. Orders are filled in the order in which they are received, and generally the first served gets the best stock. Buy direct from nurserymen, or through your association. Do not let nurserymen substitute any variety in your order. Above all, deal with reliable, well-established firms, and do not hesitate to pay a good price for good trees.

Age and Kind of Tree to Plant

The most common fault is that the biggest trees are usually planted. Trees more than two years of age have established themselves in the nursery, large roots and tops have formed, the latter pruned successively for several years with no thought given to the ultimate form of the tree or what the purchaser may require. It can readily be seen that such trees will suffer severely in transplanting. Therefore, it is best to plant one or two-year-old trees. In the progressive apple growing sections in British Columbia, Washington and Oregon, the planting of one-year-old trees is strongly recommended and generally followed. The reasons given are that they are cheaper, cost less to ship, a greater proportion of them live, and an ideal top can be secured. These reasons are very plausible, and where it is difficult to get low and properly-headed two-year-old trees it is certainly advisable to plant one-year-olds. When the trees are delivered it is of the utmost importance that they be carefully protected from exposure to the drying effects of wind and sun. Select a sheltered spot, remove the trees carefully from the cases, heel them in, covering the roots with plenty of moist earth. Do not lay out any more trees than are necessary to keep the planters supplied.

A good type of 1-year planted apple tree.



Two-year trees unpruned.

FALL OR SPRING PLANTING

In the colder section of the Province spring planting is undoubtedly the best, but in sections where the climate will permit fall planting, and where a large orchard is to be set out, considerable time can be saved by planting in the fall; but be sure that the trees are fully matured when dug in the nursery. Where the trees are immature, or the land poorly drained, serious damage may result during the winter.

PLANTING THE TREE

In order to get the trees in straight rows it is advisable to use a planting board. A planting board is simply a strip of lumber about 5 to 6 feet long, 6 inches wide and ⅞ inches thick. This board is notched in the centre and inch holes bored at each end to receive the pegs. Before starting to dig, the planting board is placed crosswise of the row with the stake marking the position of the tree in the centre notch. Small stakes are then driven in the ground through the end holes and the board taken up and laid to one side. The hole should be wide enough to accommodate the main part of the root system without crowding and deep enough to permit the tree being planted at least 2 inches deeper than it stood in the nursery row. In digging the hole the surface soil should be placed to one side in a separate pile and the subsoil in another.

Before planting the tree, some attention is usually necessary in the matter of root pruning. Long slender roots should be cut back to conform with those of the main root system and all broken or bruised roots trimmed back to the uninjured living tissue.

When ready to plant, replace the planting board and set the tree in the hole so that the trunk is in the centre notch. The roots should be spread out evenly and not allowed to bunch as is sometimes done by careless planters. Fine surface soil should then be sifted in around the roots until the roots have been covered. When the hole has been partially filled move the tree up and down slightly and quickly several times for the purpose of settling the soil around the roots. After this has been done, and as filling in progresses, the soil should be very firmly packed with the heel or a tamp. The packing of the soil around the roots is very important as it has been definitely proven that a larger percentage of the trees will grow when the soil is well firmed.

A great many of our orchards suffer severely from the trees leaning away from the direction of the prevailing winds. A great deal of this is due to the fact that they were carelessly planted. Set the young trees sloping considerably towards the west, or northwest, from which comes our strongest winds; in time they will straighten up.

Pruning the top may be done before or after planting. In the case of apples it is prefereable to do it afterwards, as the opportunity for discriminating in the final selection of a permanent head is greater. The pruning question is dealt with in detail in later pages of the bulletin.

PROPAGATION OF APPLE TREES

Before leaving the subject of planting, and nursery stock generally, a word or two should be added concerning the usual methods of propagating nursery stock. In Canada, apple trees are propagated by budding or grafting on to suitable stocks. The stocks most commonly used are the so-called French crab seedlings. The term crab is a misnomer as the seedling trees are not true crabs as understood in this country, but are produced from the seed of cider apples in

France. American grown seedlings of hardy varieties are also used to a limited extent as stocks. The great majority of apple stocks used in Ontario are of French origin as these stocks are usually cheaper than the stocks grown in the United States.

In cases where it is desirable to propagate by budding, the stock seedling trees are planted in the nursery row in the spring and grown there until late July or early August. The trees are then budded by the Shield Bud method at a point 2 inches above the ground. A large percentage of the buds inserted at this time usually take, but remain dormant until the following spring. Early in the spring the budded trees are cut back to a point a short distance above the bud. The bud usually makes a good growth during the first season and in many cases is considered large enough to be dug up and sold after one season's growth.

If the nurseryman decides to propagate his trees by grafting he uses seedling stocks or roots of one year's growth. The roots are cut into sections about 3 inches long and the scion varieties grafted on to these stocks by the Whip method. This work is done indoors during January or February and the grafts set away in damp sand or sphagnum moss until spring. In the spring the grafts are planted in the nursery row where they are grown either for one or two years as desired, before selling.

Some nurserymen use whole root grafts instead of piece roots. This adds to the expense and when it is considered that the results are but little better than with piece root grafts, there seems little to justify this practice.

With reference to the technique of grafting by the Whip method, it has been found that better results are secured when the scion is cut so that the topmost bud is on the side where the best contact is made between stock and scion. When grafts are made in this manner it is easier to get a good stand and moreover the growth from the top bud is likely to be greater than if the bud were located on any of the other three sides, particularly on the side where there is little cambium contact.

SYSTEMS OF ORCHARD SOIL MANAGEMENT

There are various systems of orchard soil management followed by growers in this province. Each one of these systems has some advantages, and likewise some disadvantages. A brief outline of these methods is therefore given so that the grower may choose the method that seems best adapted to his particular needs.

Intercropping

This method is widely used during the period between the planting of the trees and the time when the orchard reaches a profitable bearing age. Intercrops should be chosen with a view to their marketability and also in relation to their effect on the trees. Crops which require early summer cultivation, such as peas, beans, tomatoes, early potatoes are suitable for this purpose and usually command a fair price on the market. In any system of intercropping it is not considered good practice to grow one class of crop continuously on the same piece of land and therefore other crops such as clover or cereals may be grown for a change. The preference should be given, however, to those crops that require early summer cultivation as this cultivation is most beneficial to the trees. In the growing of intercrops, special care should be taken to avoid undue competition of the intercrops with the trees. This can be done by leaving a crop-free area around each tree and gradually enlarging this area as the trees increase in size.

In some sections bush fruits are grown as intercrops. However, these should not be grown except where land is high priced and it is necessary to get the maximum return from the soil. Their use as an intercrop is quite different from their use in place of filler trees, as previously discussed.

After the trees reach a profitable bearing age, the growing of intercrops is usually discontinued and the orchard soil devoted entirely to the growing of apples.

TILLAGE AND COVER CROPS

This method consists of clean cultivation during the early part of the summer, followed by the sowing of a cover crop. It is used more widely than any other system and is probably the best general method to follow except on steep hillsides or in irrigated sections.

Clean cultivation during the spring and early summer has many beneficial effects. These good effects are of course well known to the experienced fruit grower, but probably not so well known to the beginner. The following are some of the more important effects of spring and early summer cultivation:

(1) Warms and dries the soil in early spring.

(2) Supplies air to the soil and thus favours the activities of those micro-organisms that help to convert organic matter into plant food.

(3) Destroys weeds or grass which robs the trees of food and moisture. It also saves the moisture by preventing evaporation through capillary action of the soil particles.

(4) Breaks up the breeding places of some insects and thus helps to hold them in check. It also tends to reduce plant diseases through burying infected leaves, fruit, etc.

(5) Helps to prevent injuries by mice and rabbits.

In this method the soil is plowed in the late autumn or early spring. If plowing is done in the autumn the soil should be plowed toward the trees and not away. Plowing the soil away from the trees in the fall exposes the crown and roots and may predispose the trees to collar rot or root killing. Where biennial cover crops such as sweet clover, red clover, vetch, and rye and vetch are grown, it will of course be necessary to plow later in the spring, as these crops make their best growth in the spring. The time for turning under these cover crops will vary with seasonal conditions, soil and locality. Generally it will range from May 15th to 30th.

After the soil has been plowed it should be cultivated at intervals of a week until about the middle of July. After this date it is usually considered desirable to discontinue cultivation and sow a cover crop. The subject of cover crops is dealt with in detail under a separate heading.

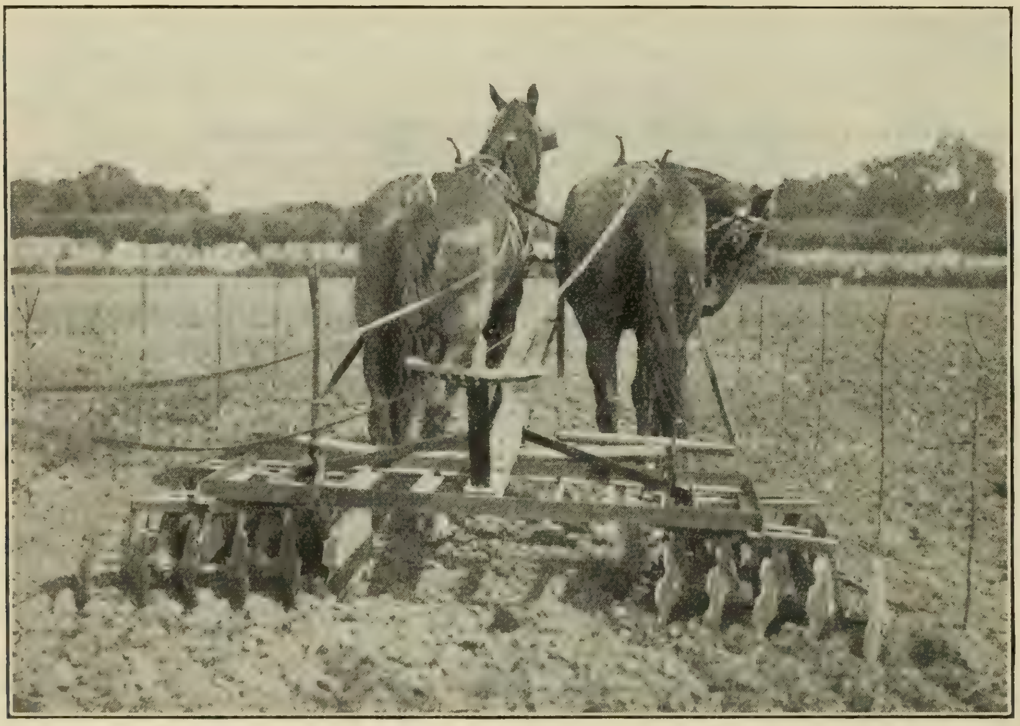
In the colder sections of the Province the usual cultivation and cover cropping programme as outlined above may have to be modified. The following is a short description of cultural methods as recommended by Harold Jones, Maitland, for the St. Lawrence and Ottawa Valleys, and is applicable to other northern sections as well:

"Actual results have proved that it pays to cultivate our orchards, but the heavy losses we sustained some years ago, brought out the problem that now confronts us in how far dare we go in this matter of cultivation and save our trees from winter injury in the colder sections of Ontario.

"Since 1904 I have been preaching a modified system of cultivation in my orchards that is giving very satisfactory results in well ripened wood and well coloured fruit of large size.

"To outline this system, I may say that instead of continuing clean cultivation until the middle of July or the first of August, as formerly, I plow as early in the spring as possible, and about the 20th or 25th of May I harrow the ground level and sow to some cover crop, either red clover or oats, as I find the fertility and the condition of the soil warrants. This leaves the ground in a level condition for the mower, which is used at intervals during the summer to check any weeds or tufts of grass that are bound to appear during the season. The last cutting is made just before picking. If oats are clipped during the summer in this way they will remain quite green until fall.

"I find this system gives me an early vigorous growth, both in the wood and fruit buds, and the cover crop sown in this way does not draw any appreciable amount of water from the soil until the latter half of the summer.



Double cutaway disc which breaks up the soil nearly as effectively as the plow.

"When cutting, allow the material to lie where it falls, as it all aids in supplying humus for the year following, and retards evaporation by wind and sun during hot, dry periods. We have got a much shorter growing and ripening season than our neighbours to the west of us, and I find the system outlined above will give the early, vigorous growth that is necessary, followed by conditions very similar to sod during the ripening season.

"Fertilizing with barnyard manure every two or three years spread at the rate of ten to twelve loads to the acre during the late fall or winter, with an annual spring application of about 100 lbs. muriate of potash, keeps the soil up to a high standard of fertility and also in a good mechanical condition."

Sod Culture

In this system the orchard is kept under grass or a mixture of grass and clover. The annual growth is cut and allowed to lie where it falls or is mulched around the trees. Some orchardists remove a portion of the grass as hay but the best results are secured where the grass is used as a mulch around the tree.

Sod culture helps to secure high colour of fruit and lessons operating costs. Possibly its chief advantage is in hilly sections where it is difficult to practice clean cultivation or where erosion is likely to occur. The disadvantages of this method as it is usually practiced are a reduction in tree growth and yield of fruit. Also the grass affords a harbour for mice and insects. If sod culture means sod neglect, as it often does, then it cannot be recommended, even for trial. However, if the sod orchard is mulched, manured, and otherwise well-cared for, the use of sod may well have a place in our orchard management systems. The cared-for sod is discussed in the following paragraph.

SOD MULCH AND MANURE

This method has given excellent results in some orchards in Ontario and, next to clean cultivation and cover crops, is one of the best methods in use. In this method the orchard is kept continuously under grass or clover, which is cut at intervals during the summer and placed under the trees as a mulch. A heavy coating of stable manure is also applied over the ground and under the trees as a supplement to the grass mulch. The manure may be applied in the winter or spring, but the best results are obtained when applied in the spring.

A combination of clean culture and sod.

Orchards in which this method has been used are giving good results in tree growth and yield of fruit, and the quality of fruit seems to be very good. This method, and in fact all other methods in which the soil space is devoted either entirely or partly to sod, demands more than ordinary care in spraying to control certain kinds of insects which are often abundant where clean cultivation is not practiced. The essentials are (1) That the cut material must be sufficient to provide a thick mulch around the trees so that there will be little or no growth of weeds or grass as far as the spread of the branches. (2) Adequate soil feeding with both manure and commercial fertilizers.

Sod Strip

The sod strip method is used to a limited extent in Ontario for apples, and to a greater extent for pears. In this method a strip of sod 6 to 8 feet wide is left on each side of the tree row, while the space between the sod strips is cultivated. The points in favour of the sod strip and sod square are convenience in cultivation and a combination of the benefits of clean cultivation and sod culture. As in sod culture one disadvantage is that mice are likely to harbour in the grass and may do some damage to the trees. Another disadvantage is that insects may be more difficult to control where this method is used.

Sod Square

This method consists in leaving a square of permanent sod around each tree and in following tillage and cover cropping on the remainder of the orchard space. Those who follow this method usually make a practice of plowing crosswise in alternate years, thus leaving the tree in a square of sod. The points for and against this method are the same as in the sod strip.

Alternate Sod Strip

This is a variation of the ordinary Sod Strip Method. Every other land is left in sod, preferably clover, for a full season, while the remaining lands are clean, cultivated in the ordinary way. The following season, the lands are reversed, the sod being ploughed down and kept clean, while the clover cover crop on the past season's clean cultivation lands is allowed to grow. It should be mowed of course two or three times during the season, the cut material being allowed to lie where it falls.

This method is less costly than complete clean cultivation and cover cropping, and is an economical method of supplying the soil with humus-forming material and with nitrogen.

Where this method is in use the trees are making a good growth and are bearing heavy crops of fruit. The alternate strip method has been used at the Horticultural Experiment Station at Vineland for several years, with very good results, and is recommended for trial in commercial orchards. This method has been used in Nova Scotia where it is known as the Johnson Method.

PREVENTION OF GIRDLING

Where any system of sod culture is followed, trunk girdling, particularly from mice, is likely to prove a problem.

The old saying that prevention is better than cure is especially applicable to the girdling of fruit trees. All the injury usually done by mice and most of that done by rabbits may be more easily prevented than repaired.

For this purpose galvanized wire screen of ¼ inch mesh makes an effective protection. This material may be purchased in squares ready for application or it may be obtained in rolls and cut into suitable dimensions. Pieces 18 inches by 18 inches are considered large enough for most trees. When ready to apply the wire, take the sheet and roll tightly around a 2-inch pipe or other roller. Withdraw the pipe and unloosen the roll enough to allow it to loosely encircle the trunk, taking care to set the lower end about an inch in the soil. Wire screen protectors are more costly than tar paper or heavy building paper, but are much more effective and durable and as one application is usually enough are really cheaper in the long run.

Some protection may also be secured by cutting off small branches in the late autumn and scattering these on the ground throughout the orchard as a food supply for the mice in the winter.

Poisoned baits may be used effectively if care is taken in distributing the materials. The following is a good formulae: Strychnine, ½ ounce; boiling water one pint; syrup, one pint. Boil together for a few minutes and stir thoroughly. Sprinkle this solution on oatmeal, taking care to thoroughly moisten the meal. Scatter the meal in teaspoon lots around the orchard under grass, weeds, boards, brush or place in small drain tiles. If distributed in this manner the mice will likely get the poison, while the birds will not be destroyed.

Where trees are not protected by wire screens, tramping the snow around the base of the trees in winter is a good practice.

Hawks and owls which have not developed poultry stealing habits should be protected as they destroy large numbers of mice.

A repellent wash made of lime-sulphur has been recommended, but this has not always had the desired effect. It may serve as a repellent for mice but it does not keep rabbits away. In a young orchard near Aylmer which had been treated with this wash, more than 150 trees were so severely injured by rabbits that they had to be cut off at the ground and regrafted on the stump or replaced by other trees.

Clean cultivation is another important factor in preventing girdling, but even this is not wholly effective when adjoining areas are kept in long grass. Because of this it is good practice to use tree protectors of some kind.

If injury has occurred, bridge grafting will need to be resorted to. The reader is referred to Bulletin 324 on grafting fruit trees for full directions.

COVER CROPS

Cover crops, like cultivation, exert many beneficial effects, the chief of which are noted below:

(1) Check late growth and thus help to prevent winter injury.

(2) Help to catch snow and indirectly serve to prevent deep freezing and root injury.

(3) Add humus forming material to the soil and thus help to keep the soil in good physical condition.

(4) Where leguminous crops are used, nitrogen is added to the soil in one of the cheapest forms.

(5) Prevent erosion on uneven surfaces.

(6) Catch and hold soluble plant food.

Classes of Cover Crops.—Cover crops are generally classified as leguminous and non-leguminous. The leguminous group includes red clover, sweet clover, hairy vetch, cow peas, soy beans and horse beans. Of these, sweet clover, mammoth red clover and hairy vetch are the most widely used and probably the best. Sweet clover has given very good satisfaction and is now quite extensively grown. The seed can generally be purchased at a low cost, and a good germination is usually secured. It comes on early in the spring and makes a good growth before most other plants, thus permitting of plowing in before warm, dry weather comes. The roots are large and penetrate deeply into the soil, keeping it open and friable.

In the non-leguminous class there are oats, rye, buckwheat, Japanese millet, turnips and rape. These crops are well known and have been widely used as cover crops, and hence do not need more than a passing reference.

In the above list oats and millet have given very good results. Both of these crops make a fairly rank growth and furnish a lot of organic matter which can be turned under in the fall if desired. They are also killed by the first heavy frost and therefore do not take moisture from the trees late in the season.

Buckwheat is also a useful crop to sow, especially on heavy soils as a nurse crop for sweet clover. When sown as a nurse crop, it should be allowed to come into bloom and then cut and left on the ground as a mulch.

Amount of Seed to Sow.

Leguminous:	Amount per Acre
Sweet Clover	12–15 lbs.
Red Clover	10–12 lbs.
Hairy Vetch	1 bus.
Cow Peas	1½ bus.
Soy Beans	1 bus.
Horse Beans	1 bus.
Non-leguminous:	
Oats	1½–2 bus.
Buckwheat	3 pecks
Rye	1½ bus.
Turnips	6 lbs.
Rape	6 lbs.
Japanese Millet	2 pecks

When to Sow Cover Crop Seeds.—The time to sow cover crops is determined by soil and seasonal conditions. In warm dry seasons it is advisable to sow later than in seasons when there is an abundant rainfall, and on soils that are more susceptible to drouth sowings should likewise be later. As a general statement cover crops are sown about the middle of July.

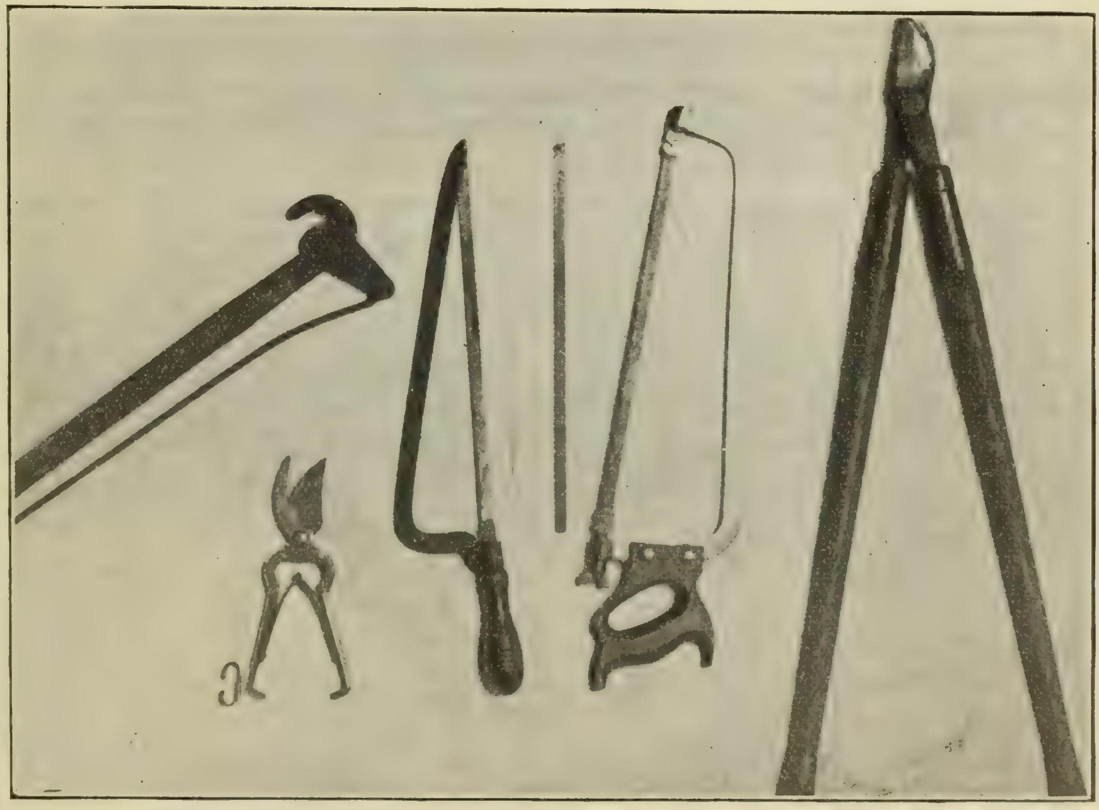
FERTILIZERS

The fertilizer recommendations formerly made for fruits have been based largely on the plant food requirements of field crops, particularly cereals. These recommendations included the use of nitrogen, potassium, and phosphorus as essentials for the best results in growth and yield. Recently completed investigations, however, show that the food requirements of cereals and fruits are quite differerent and that the old recommendations are not entirely sound.

These studies show that nitrogen is very often the limiting factor in fruit soils. This element makes a vigorous growth of stem and leaf and is an important factor in the formation of fruit buds and in securing a good set of fruit. Nitrogen may be incorporated in the soil by the addition of stable manure, leguminous cover crops or by nitrogen bearing fertilizers. Where stable manure is readily available it should be used, not only for the nitrogen which it contains, but also because it furnishes organic matter to the soil. This organic matter decays and forms humus, which is the basis of soil fertility. Without the presence of humus, heavy soils will bake and become very hard in dry weather, and light soils will suffer more severely from drouth. The principal food requirements of plants, that is, nitrogen, phosphorus and potassium, may be in the soil in abundance, but without a good supply of humus the soil will not be fertile. In other words humus is the conservator of these important plant foods. Cover crops ultimately furnish humus when ploughed under and may be used as a substitute for stable manure. As previously noted, when leguminous cover crops are grown nitrogen is restored to the soil through the action of nitrogen fixing bacteria which operate in the nodules on all leguminous plants. These plants are, therefore, more valuable than non-legumes and should be given the preference in the choice of cover crops.

Where barnyard manure is used, it should be spread on the ground from a point about two feet from the trunk, to somewhat beyond the spread of the branches. The practice of piling manure close around the trunk of bearing trees is a mistake, as the feeding rootlets are found at some distance from the trunk, moreover there is a possibility of injury from mice and collar rot where manure is placed close to the tree trunk.

The nitrogen requirement of apple orchards could in all probability be met by moderate applications of stable manure and the plowing under of legumes. If this treatment does not produce the desired results in growth or fruitfulness, commercial fertilizers such as nitrate of soda or ammonium sulphate should be used as a supplement. The quantity to use will be determined by the size and condition of tree. A general rule followed by some orchardists is to use one-quarter pound per tree foi each year of its growth.



Modern pruning tools.

Phosphorus, or phosphoric acid as it is usually called, is present in most soils in sufficient quantities for the needs of tree fruits, and therefore applications of this fertilizer are not likely to be of value to the trees directly. This element, however, often stimulates the growth of cover crops, and therefore is of indirect value to the tree, in producing growth and fruitfulness. Where the growth of cover crops is not satisfactory, applications of phosphatic fertilizers such as acid phosphate, bone meal, or phosphate flour would probably be beneficial.

Potassium, like phosphorus, is usually present in sufficient quantities and hence is not needed.

Calcium, or lime, is not a fertilizer but is valuable because of its physical and biological effects on the soil. Lime corrects soil acidity and is thus of benefit in growing leguminous cover crops. It makes available other elements such as potash and also helps to make heavy soils more friable and open. On soils that are heavy and which tend to bake or where it is difficult to grow legumes because of acidity, applications of lime would seem to be warranted. Agricultural limestone is one of the cheapest and most satisfactory forms and generally gives satisfactory results when applied at the rate of one to two tons per acre every three or four years.

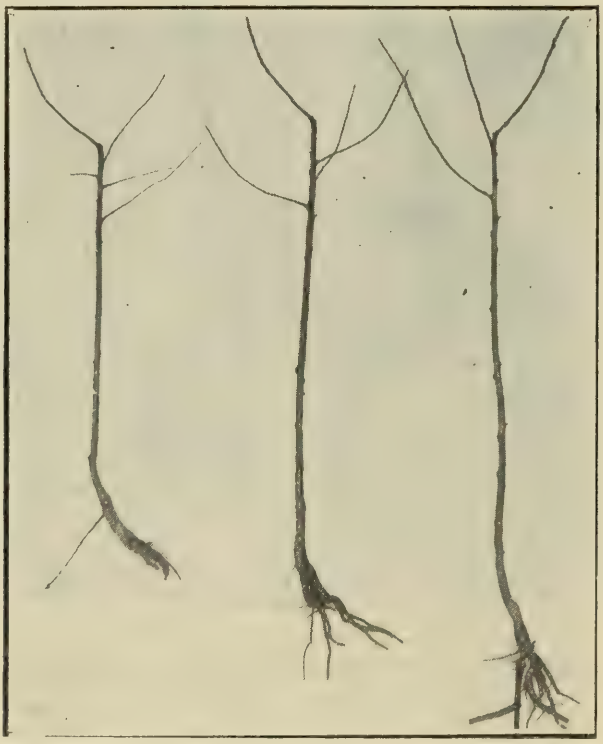
PRUNING

Pruning is an important orchard practice and one that exerts a marked effect on tree growth and fruitfulness. The object of pruning is to modify the form of the tree and to regulate the quantity and quality of fruit produced.

In the following pages, an attempt will be made to give a general outline of the practice of pruning as applied to the training of young non-bearing trees, and also the general methods employed after the trees reach bearing age. For convenience the discussion on the pruning of these two classes of trees will be presented under separate headings.

NON-BEARING TREES

In the pruning and training of young apple trees there are three methods followed in this province. These are the open centre, the central leader, and modified central leader. These methods involve slightly different details for each and consequently can best be dealt with under their respective headings.



Two-year trees pruned.

Open Centre.—This form of tree is used to a certain extent in Ontario and other eastern apple sections. The open centre tree usually consists of three to five foundation branches well distributed around the circumference and extending upward and outward. From these foundation branches laterals develop and form a tree with a vase-like outline.

Trees formed by this method are inclined to be weak at the crotch and occasionally branches break away, making the tree lop-sided. The open centre tree permits light to enter freely and thus favours good colouring of fruit.

The following suggestions on the training of the open centre tree may be of use in guiding the grower in securing a tree of this type.

At the time of planting the tree should be given some heading back to help restore the balance between top and root. In the case of one-year trees the top is cut back to a point where it is desired to have the head formed. This will vary with the preference of the grower and the condition and variety of tree. As a rule, most apple trees are headed at a height of 2½ to 3½ feet. As a result of this heading back several laterals will likely grow on the upper part of the tree during the first season. The best of these laterals are selected in the spring of the second year to form the foundation branches of the new top. Where soil and climatic conditions are favourable, the new growth will attain some length and consequently may need to be headed back. The actual amount of cutting back will vary with the length and position of the branch. It should not be much in any case. For the young tree too little pruning is better than too much. The upper branches of a tree usually grow longer than those lower down and therefore when cutting back is performed, those at or near the top should be shortened more severely than the lower ones. As a rule the orchardist should endeavour to leave the ends of the main branches on about the same level. In the second season of growth, the primary scaffold branches are likely to produce several laterals. From these laterals two of the best on each branch are selected to form the secondary branches and the rest removed. In selecting these laterals, care should be taken to choose those that are on the horizontal plane if possible and to leave some space between each lateral.

In the case of two-year trees, there are generally numerous branches already formed. The selection and general treatment of these branches is much the same as for one-year trees in the second year of their growth.

Modified Central Leader.—The modified central leader tree is a combination of the open centre and the central leader. It possesses the good features of both and is a method that should be more extensively followed. Trees of this type are formed by selecting a leader shoot or other upright growing branch and letting this grow to a height of 6 or 8 feet above the point where the head is started. The remaining laterals are shortened in to allow the leader to make the greatest growth. This central leader usually produces numerous laterals from which foundation branches may be selected at suitable points. In choosing these laterals, care should be taken to have them well distributed around the circumference and along the vertical axis. From 5 to 7 are left for the main frame-work branches and these in turn are usually headed back as a means of getting more lateral where they are needed. In some cases, however, no heading back is done, the main laterals being allowed to grow undisturbed. After the desired number of foundation branches has been obtained the central leader is cut back and kept suppressed.

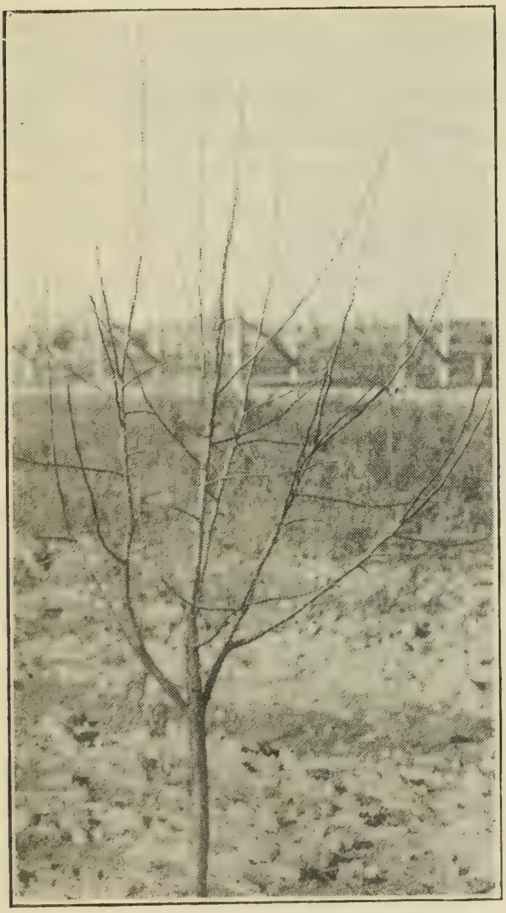
Central Leader.—The central leader tree is one in which a central branch is allowed to grow vertically with little or no heading back while the lateral branches are kept shorter by more or less cutting. This method of training usually produces a tree with strong crotches and consequently very little breaking down of branches occur. The central leader is not used to any extent in Ontario. The disadvantages of this method are that the top is liable to grow too high and it is somewhat difficult to keep open enough for free entrance of sunlight and air.

THE EFFECT OF PRUNING ON GROWTH

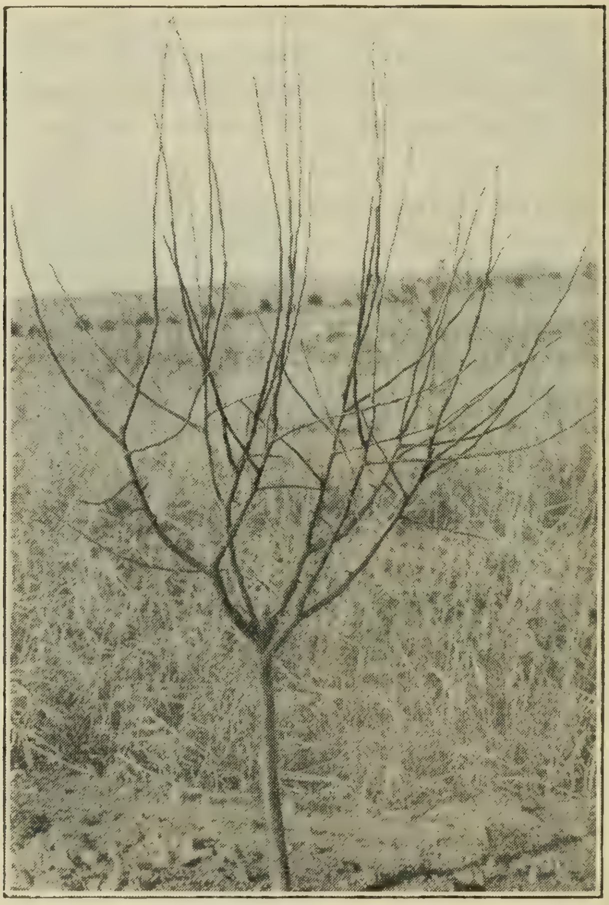
Generally the principal point to be considered in the formative pruning of a young apple tree whether open centre, modified central leader, or central leader, is to select those branches which will make a strong well-balanced tree with a good distribution of fruiting wood around the circumference and throughout the outer two-thirds of the head.

In actual practice it may be somewhat difficult to get the trees to conform to any well-defined scheme of training, and consequently the orchardist will have to take the tree as it is and work toward the above mentioned ideal.

After the head has been formed, corrective pruning only is necessary, until bearing age is reached. The heavy annual cutting back and thinning out of young trees, which has been practised so extensively in past years, serves no useful purpose, and in fact actually dwarfs the tree and delays fruiting. As previously stated it is better to give the young non-bearing tree too little pruning rather than too much, delaying the heavier cutting until bearing age.



Duchess Apple, 3 years planted.
Pruning should consist of a very little thinning out only.



Duchess Apple, 3 years planted.
In pruning, little more thinning out required than for the tree on the left.

Experimental work at Vineland and elsewhere has shown that the unpruned or lightly pruned *non-bearing* tree actually makes a considerably greater total wood growth, than the more severely pruned tree, and *also comes into bearing earlier*. Pruning therefore does not make for an increase in growth, but rather inhibits growth. True, after dormant pruning there is an immediate growth from just back of the cut, of long thick sappy wood, the amount of such growth depending upon the severity of the pruning. Growth is thus *apparently* induced by pruning. But these sappy growths are not sufficient to make up for the amount of wood cut off plus the normal amount of growth that would have taken place on this pruned-off wood. In this case, therefore, pruning simply alters the type and direction of the new growth. In the lightly pruned young tree there is an even distribution of new growth in every part of the tree, the aggregate growth being sufficient to make it a larger tree than if heavily pruned. In the heavily pruned tree the wood cut off is not wholly made up for by the new growth induced.

The underlying reason for the unpruned or lightly pruned young tree being larger than the tree receiving more severe treatment is in reality very simple and logical. The soil may contain an abundance of proper plant food and the root system may be well able to absorb it but this "raw" food must first go to the leaves and be there manufactured into "available" food before the tree can make use of it. The roots themselves must receive some of this manufactured food before they can grow and develop further. Pruning, by removing part of the possible leaf area of the tree, reduces by just that much the ability of the tree to manufacture plant food and the tree therefore does not make the amount of growth that it would if unpruned.

We see therefore that, theoretically, the more severe the pruning the tree receives, the more will its growth be retarded. That this theory is absolutely correct is amply borne out by the great amount of experimental evidence resulting from work being carried on at various Experiment Stations.

Not only is the above true, but it is also true that the more moderately pruned tree, a tree in which the pruning is too little rather than too much, has a stronger framework better able to carry the maximum load of fruit. The heavily pruned tree ordinarily has many comparatively weak crotches and joints. The sappy growth incident to heavy pruning is not a strong growth. It is not strongly attached to its parent limb. The normal and natural growth in a tree consists in the pushing out of new growth from the terminal buds and such growth is the strongest that is made. This suggests that when a tree requires pruning, cutting back to buds should not be practiced but rather the whole limb should be removed or the branch shortened back to a side branch, this side branch carrying on the growth of the limb. This kind of pruning will tend to keep the tree more open. When promiscuous cutting back of the young wood to buds is practiced, two or three of the buds just back of the cut will start into growth with the result that further pruning will be necessary to remove the surplus young branches, otherwise the tree will become bushy.

HEAVY PRUNING DELAYS FRUITING

Thus far we have dealt only with the effect of pruning on the growth of the tree. It has also been mentioned that pruning, particularly heavy pruning, delays fruiting. Let us consider the underlying reason for this.

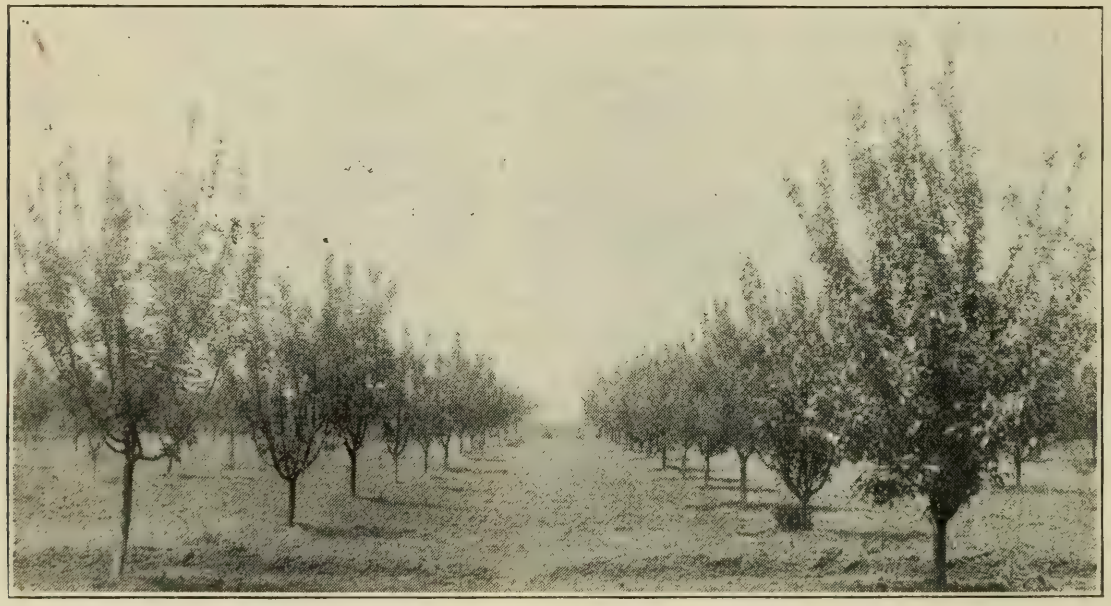
Briefly, it may be stated that there are two main classes of food which enter into the plant or tree. These classes of food are,—

(1) The moisture and mineral food or soil nutrients, principally *nitrates*, but including also potassium and phosphoric acid which are essential to the manufacture of the finished food.

(2) The *carbohydrates*, the sugars and starches which represent the finished food manufactured in the leaves. This manufactured food is stored principally in the branches, twigs, and fruit spurs.

What have these foods to do with pruning? It has been established that a certain proper balance between the above two factors, nitrates and carbohydrates, or raw food and manufactured food, gives proper growth and fruiting in the tree. Therefore the fundamental principle underlying pruning is to first establish this proper balance and then, when the tree comes into bearing, to maintain it. It must be remembered, however, that pruning is only one means of maintaining this balance. Soil fertility is, if anything, more important. Trees on soil too rich in raw food will continue drawing from the soil large quantities of this raw food. This abundance of raw food will delay the establishing of the proper balance between the nitrates and carbohydrates and will therefore delay fruiting. Pruning, therefore, should be regarded not as an independent cultural operation, but rather as being correlated with other factors, particularly soil fertility and cultivation. However, we shall discuss here the effect of pruning only on the bearing of the tree.

We have all observed that the fruitful tree is a tree of moderate annual growth. Similarly, the unfruitful tree, if young, is a comparatively rapid grower; or if old, is making little or no new growth. Chemical investigation shows us that the vigorous unfruitful tree is high in "nitrates" as compared with "carbohydrates"; the unfruitful tree of poor vigour is just the reverse, while the fruitful tree of moderate growth has a comparatively "balanced" condition.



Heavily pruned trees on left, lightly pruned on right. Note larger size of the lightly pruned.

Pruning of vigorous unfruitful trees removes part of an already inadequate supply of manufactured food (since, as previously stated, this manufactured food is stored in the small branches, twigs, fruit spurs, etc.) and therefore makes the proportion of carbohydrates to nitrates worse instead of better. Fruiting of the young tree is thereby delayed.

The impression should not be gained from the foregoing that young trees require no pruning. It is recommended, however, that there be more moderation in the pruning of young fruit trees until they reach bearing age, than has heretofore been generally considered advisable. As previously mentioned, no pruning, or light pruning will give a larger and stronger tree and a tree which will come into bearing earlier than where more severe pruning is practised. The unpruned or insufficiently pruned tree, however, especially in some varieties, may grow too straggly and thick, requiring too severe treatment after it comes into bearing. We might possibly get a better conception of the question if we would consider the pre-bearing period as a "training" period for the tree where such pruning as is given is "corrective", consisting in the removal of undesirable branches and having as its object a well-balanced tree. After bearing age, pruning practice should have as its object the maintaining of the tree in fruiting condition by insuring a sufficient amount of new growth annually. Annual pruning and sufficient feeding will give this desired result.

PRUNING THE BEARING TREE

The pruning of the bearing tree calls for somewhat different treatment than the non-bearing tree. Sufficient pruning should be given to keep the tree properly open, and to encourage moderate new growth each year. The following suggestions will serve as a guide:

(1) Cut out broken, dead, or diseased branches.

(2) Where two branches closely parallel or overhang each other, remove the least desirable, taking into account horizontal and vertical spacing.

(3) Prune on the horizontal plane, that is to say, leave those laterals on the main branches that grow horizontally or nearly so and remove those that hang down or grow upward. This cannot always be done, but where possible it should be followed.

(4) All varieties should be thinned out enough to permit of thorough spraying, and the entrance of sunlight and air. Close-topped varieties such as Spy and Transparent will require somewhat heavier thinning than the more open varieties.

(5) Where it is desired to reduce the height of tall trees, cut the leader branches back moderately, to a horizontal lateral if possible.

(6) The lower branches of broad-headed or drooping varieties such as the Rhode Island Greening, should be pruned to ascending laterals.

(7) Varieties which tend to produce numerous twiggy, lateral growths, should have some of these removed to prevent overcrowding.

(8) Make close, clean cuts. Stubs are unsightly and often decay, thus forming a source of injury to the parent branch or trunk.

(9) Prune moderately. Very heavy pruning is likely to upset the balance between wood growth and fruitfulness, and generally should be avoided.

(10) Prune regularly. Trees which are given some attention each spring are more easily kept in good condition than trees that are pruned irregularly.

(11) Distribute the pruning throughout the tree. This is particularly important with old trees. New growth, will be stimulated only in those parts of the tree where pruning has been given.

(12) Do not remove a branch unless there is a very good reason for doing so. It should not be forgotten that the leaves of a tree are the food-manufacturing organs, and if the leaf area is reduced unnecessarily the tree will be injured in growth or fruitfulness or both.

TIME TO PRUNE

It has been said that the time to prune is when your knife is sharp. There is probably a measure of truth in this statement, but it is not a safe rule to go by, because some people never have a sharp knife.

Pruning is better done in the spring, preferably before growth starts, but in case it is impossible at that time it may be done immediately after the trees leaf out. It is desirable to have the wounds, particularly if large, heal as rapidly as possible to prevent decay. When pruning is done in the autumn or early winter, the cambium layer is likely to die and the wood dry out and split. It is obvious, then, that pruning is best done when the healing process is about to commence. This applies particularly to northern sections. In southern Ontario, no serious damage has resulted from winter pruning. In cases therefore where a large number of trees have to be pruned, it would seem advisable to do the work at any time during the dormant season when weather conditions permit.

FRUIT THINNING

Modern orcharding takes into account every possible means to increase the quality of the fruit produced. Briefly stated (1) thinning lessens the drain upon the tree occasioned by overloading. (2) The fruit is larger and of more uniform size, factors especially important for box packing. (3) The fruit is more uniformly coloured. (4) Trees are less likely to break under the strain of overloaded limbs. (5) The percentage of culls is greatly reduced. These are potent facts and the success of profitable box packing depends very considerably upon proper thinning.

One thinning is sufficient if done severely. The great trouble with beginners is that they do not remove enough fruit. If the tree is heavily loaded, the apples should be thinned to a single fruit to a cluster. The remaining apples should be five to six inches apart. If the clusters are closer than this remove all the fruit from some.

Commence to thin your apples immediately after the June drop, choosing the heaviest laden trees first, and thin to from five to six inches apart. The heavier the load the farther apart. Remove all wormy and misshapen fruits. The quickest and easiest way is to use the thumb and forefinger; shears are now on sale that will do good work. Early thinning is best, beginning three or four weeks after the fruit sets, even if the June drop is not quite over.

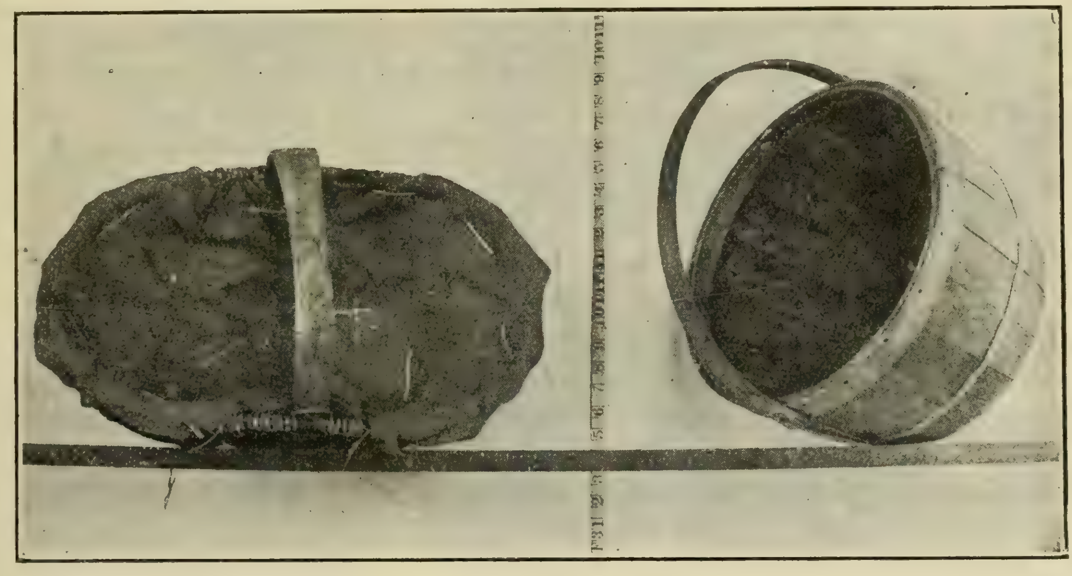
The cost of thinning will vary greatly, depending upon size of crop and trees. Large heavily laden trees may cost from fifty cents to a dollar. This cost though will not appear so great when the lessened cost of handling the ripened fruit is taken into consideration. The opinion of our most up-to-date and successful orchardists is that judicious thinning pays. This much is certain, that if we wish to make a success of box packing we must thin.

PICKING

Turning from the labour and expense of the season's operations to harvesting the crop is a pleasure indeed. A bountiful crop stimulates one to further efforts and study for the following season. Successful growers who have worked out a system of picking for themselves after long experience are exercising a great deal more care in the handling of their fruit than formerly. The test of carefully picked apples is in the storage after being stored until May. If you will examine decayed apples in a storehouse you will find a large percentage of them have a small puncture of the skin in the centre of the decayed spot. It may be a stem puncture, an insect bite or a puncture caused by being dropped into an unlined wicker basket. Whatever the injury is from, it causes decay. It is quite certain that the method of handling the fruit has more to do with the profits than most growers will concede.

PICKING UTENSILS

Light ladders are the first essentials, as they are easily handled. Heavy ladders take time to move, are a worry to the pickers, and owing to their unwieldiness when moving, a great many apples are bruised and limbs broken. Very handy ladders are now being made especially light and strong. Those with the sides coming together in a point at the top are good. Three-legged ladders for picking in the lower part of the tree are also necessary. Various kinds of baskets are in use, but the best are those made of oak or elm splints. They are superior to the wicker baskets for the reason that they are smoother and bruise the fruit less. A very convenient basket is one made of oak splints with a swinging handle. All baskets, even the smooth ones, should be lined with several thicknesses of canvas or gunny sacking. Attach an iron hook of quarter-inch material to the handle. Ordinary wooden pails are sometimes used, but they are of doubtful convenience. Where three-legged step ladders are used they have been found to be handy, and are used very extensively on the Pacific Coast. Patent picking buckets are very good, but unless tried and not too expensive, one should not get them. Canvas bags fastened over the shoulders, with an opening at the bottom sometimes controlled by a draw string, are also used. They hold a large number of apples, but in reaching and coming down the adder a great many apples are bruised against the rungs and limbs.



Picking baskets.

PICKING FOR STORAGE

In a large orchard the proprietor should devote all his time superintending the pickers, insisting upon careful handling of the fruit and trees. Careless pickers break a great many limbs and destroy countless fruit buds.

Apples should be picked with the stems on, not torn from their stems. Torn skin will admit decay germs more readily than bruises, and as this is a source of considerable loss the pickers should be mindful of it. Give the apples a twist and upward or downward pull. If this is done, few stems will be pulled out.

It is commonly believed that unripe apples keep best. This is not a fact. Our experience has been that properly ripened apples keep much better than mmature ones. An apple to keep long, should be well coloured for the variety and require a firm pull to pick. Apples that separate from the tree by being slightly raised are overripe and should be marketed at once.

Where the fruit is to be stored for later packing, it should be sorted in the orchard at once to remove all culls. The good fruit may be placed in barrels and the heads put in, using very little pressure when heading up. For immediate shipment, grading and barreling can be done in the orchard. Another good method is to place the fruit in open bushel crates, stacking these in the packing house till required. A cleat on each side of the top will prevent bruising. Apples should never be piled on the ground, nor picked when wet. Whether storing in cellar or cold storage or for shipment, handle them quickly.

MARKETING

To one of the methods which has been adopted and is still in operation in the marketing of our apples is due the unstable condition of the apple market and has been heretofore the chief reason for the lack of interest which the farmers have apparently shown towards their orchards. This system may, for convenience, be called the "Lump system." As soon as the apples have become fairly well developed the apple dealer drives around the country buying up the fruit on the trees for a lump sum. If the season is not very favourable at this time, he holds off unless some competition arises in the shape of other buyers. This system of selling is a mere gamble, with the farmer generally losing. In the majority of cases the crop is under-estimated. The farmer gets a price that is below the normal market value. He probably has to board a lot of pickers, who, besides being an expense to him in this manner, are usually careless and break a great many limbs and destroy countless fruit buds.

Undoubtedly the best method of marketing is co-operatively. Successful co-operation in marketing gives the farmer every dollar and cent that is in the fruit. Specific instances can be given to show by comparison the advantages of this method and where once adopted and the association properly organized, very few instances of failure can be shown.

COLD STORAGE

The commercializing of our apple orchards necessitates the careful handling of the crop in every particular, not the least of which is storing. Cold storage is something everyone cannot have on his farm, but with the formation of co-operative associations we may look to the ultimate establishment of cold storages in a great many apple shipping centres. The chief advantage of cold storage, so far as fruits are concerned, is to prolong their seasons which, of course, means increased consumption. A certain amount of waste will occur, but by choosing the right varieties at a proper stage of maturity and handling them just right this loss can be greatly controlled.

In Western Ontario the Greening is largely grown, but owing to its poor keeping qualities there the fruit is marketed early and often suffers from low prices due to gluts. This variety keeps much longer in cold storage when stored promptly after picking, and will hold until long after the New Year. It is in good demand in all of our Ontario markets on account of its excellent cooking qualities, and would sell at much better prices if the season was extended. As a result of extensive experiments it has been proven that this and other varieties from Western and Southern Ontario can very profitably be cold-stored, both for local markets and for export.

Aside from the generally accepted idea of the benefits of cold storage, there is another phase of the problem which is deserving of consideration. This is the equalizing of prices. In May and June apples are almost out of the market, and good ones cannot be had, even at exorbitant prices. With cold storage convenient to the farmer, a higher price could be paid him in the season of good crops, and by storing an abundant supply could be offered the consumer at greatly reduced prices. This is plainly of advantage to both. A practical and inexpensive cold storage for fruit growers is becoming more and more a necessity for the handling of the crop at the most profit. The crude, old-fashioned ways of storing apples in pits, etc., though still practised, are fast giving way to more modern methods.

TOP GRAFTING THE APPLE

In recent years there has been a renewed interest in the ancient and useful practice of top grafting. This is due, largely to a desire on the part of fruit growers to convert unprofitable varieties into varieties having better market qualities.

Top-working young trees.

Young Apple tree, topworked. Third year after grafting.

Top grafting is also effectively used as a means of growing varieties which have some inherent weakness in the trunk.

For further details on top grafting, bridge-grafting, etc., see Ontario Department of Agriculture Bulletin No. 324, "Grafting Fruit Trees."

INSECT PESTS AND DISEASES

The apple, in common with other tree fruits, is attacked by various insects and plant diseases.

The chief diseases are apple scab, sooty blotch, black rot canker, pink rot, Baldwin spot or stippen and bacterial blight.

Among the more destructive insects attacking the apple are codling moth, railroad worm, tent caterpillar, aphids, canker worms, San José scale, oyster shell scale and green fruit worm.

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Ontario Department of Agriculture

HORTICULTURAL EXPERIMENT STATION

Vineland Station, Ontario

GRAFTING FRUIT TREES

By JAS. A. NEILSON, B.S.A., M.S.

Grafting is an old and very useful horticultural practice. History does ot definitely record when the practice originated, but it is known that it was ollowed by Roman horticulturists several hundred years before the Christian ra. Since the discovery of the art it has been extensively developed, and now used in all countries where fruit trees are grown.

Grafting may be defined as an operation in which a twig or a piece of ark containing one or more living buds is cut from one plant and inserted a cleft or incision made in a piece of root, or the stem or branch of another lant, in such a way as to insure a continuation of growth.

Baltet, a French writer, in his book on grafting, mentions forty-seven ethods of grafting in use by expert horticulturists in France. The present ulletin, however, is not intended as a complete treatise on grafting, and there-re only those methods which are of greatest value to the Ontario fruit grower ill be discussed. The methods described herein are as follows: Cleft Grafting, ark Grafting, Whip Grafting, Strap Grafting, Channel Grafting, Bridge rafting and Bud Grafting or Budding, as it is generally called.

Meaning of Terms Used in Grafting

1. Stock: The portion of root, stem or branch on which the scions or buds e placed.

2. Scion: A section of a one-year-old branch containing one or more living ds. The part which is inserted on the stock.

3. Cambium layer: A thin layer of soft greenish coloured tissue situated etween the bark and the wood. It is the growing part of the tree.

4. Bud-stick: A small branch of the current season's growth from which e buds are cut.

5. Bud: A living bud cut from a bud-stick.

6. Raffia: A strong pliable tying material used to hold the buds in place the stock. It is widely used for the purpose and is carried in stock by seeds-en and florists.

Objects in Grafting

Grafting may be used: (1) to renovate or top-work a tree; (2) to repair jury to trunks or branches; (3) to propagate varieties.

(1) RENOVATION OR TOP WORKING

The renovation of fruit trees is often desirable and may be accomplished by different methods of grafting such as Cleft Grafting, Bark Grafting, Strap Grafting, Whip Grafting, Channel Grafting and Budding. Top-working is the term generally used to designate this process which is made use of for the following purposes:

1. To Improve the Quality and Size of Fruit

Varieties (or seedlings) which are undesirable because of small size or poor quality of fruit may be changed over and made to bear fruit of larger size and good quality by top-working with any variety possessing these characteristics.

2. To Secure Earlier Fruiting

Certain varieties which take a long time to come into bearing may sometimes be brought into bearing earlier by top-working them on early maturing less vigorous varieties. Grafting some varieties of the pear on the quince stock is known to hasten the production of fruit.

3. To Obtain Greater Disease Resistance

Fruit trees—the cultivated pear for instance—are subject to a very destructive disease, bacterial blight. It has recently been found that pears may be made more blight resistant by growing blight resistant stocks such as *Pyrus Ussuriensis* or *Pyrus Calleryana* and top-working these with good commercial varieties.

4. To Secure Greater Hardiness

Varieties which when grown upon their own trunks are subject to forms of winter injury such as collar rot, sunscald, or crotch injury, may be grown successfully by top-working on hardy varieties planted for the purpose. The King top-grafted on Tolman Sweet, or Grimes on Virginia Crab or Hibernal are examples of the use of grafting as a factor in growing semi-hardy varieties on hardy stocks.

5. To Correct Pollination Difficulties

Some varieties of plums and all varieties of sweet cherries when grown in solid blocks of one variety fail to set fruit owing to self-sterility. This difficulty may be overcome by grafting a few trees here and there or a few branches with scions of varieties known to be good pollinators.

Adaptation of Various Methods to Different Kinds of Fruit Trees

Apple, Pear and Plum trees may be readily top-worked by various method of grafting and budding. The method used will, of course, vary with the size of the trees. Peach, Apricot and Cherry trees respond more readily to budding than to grafting.

Fundamental Conditions to be Observed in Grafting

1. The stock and the scion must be closely related in order to facilitate those physiological processes of growth which are necessary for a union.

2. The cambium of the stock and that of the scion must be brought closely into contact at some point. The greater the area of contact of these layers of tissue the more certainty there is that a union will be formed.

3. All clefts or incisions must be properly covered with wax or other equally good material after the scions or buds have been inserted. This is necessary to prevent the loss of moisture and the entrance of decay or disease-producin organisms.

4. With nut trees and sweet cherries much better results are obtained when the scions are entirely coated with liquid paraffin wax. The wax prevents desiccation.

5. The operation must be performed at a time suitable to the style of grafting used.

6. Careful, accurate work is necessary in cutting and fitting the scions or buds to the stock.

7. The scions or buds and the stock must be in a healthy condition.

8. The stock and the scion should grow at about the same rate.

Selection of Scions

Scions are made from well ripened wood of the previous season's growth and should preferably be taken from the outer, upper branches of healthy trees of the desired variety. In cases where it is difficult to get good scion wood from the terminals, it is quite permissible to use sucker growth from the central part of the tree. Scions made from suckers have given good results notwithstanding the general belief to the contrary.

Scion wood may be taken any time from late autumn until the sap begins to flow in the spring, but the best results are likely to be obtained if the scions are taken shortly before growth starts in the spring. In sections where low winter temperatures prevail and the scion wood is liable to frost injury it would be better to take the scions in the late autumn or early winter before severe weather sets in. In such cases the scions should be stored in a suitable medium such as moist sand, leaves, moss or sawdust, and placed in a cool cellar or ice-house until wanted for grafting.

When Grafting May be Done

The time for grafting varies somewhat with the method used. Cleft, Channel and Whip Grafting should be performed just before growth starts in the spring; but Bark, Strap and Bridge Grafting are best done a little later when the sap is flowing freely. If the scions are in a dormant condition, Bridge Grafting may be done even when the trees are in bloom. Budding is usually done in July or August when the sap is flowing freely and the bark will slip easily.

Selection of Branches for Grafting

There is hardly any limit to the size of branches on which scions may be made to grow, but there is a limit, however, to the size of branches which can be grafted and made to heal over properly. In actual practice it has been found that cuts on branches above three inches in diameter are hard to heal over, and therefore it is best to confine grafting to branches under this size. For practical purposes, branches ranging from three-quarters up to two and one-half inches in diameter are best for the common methods of grafting such as the cleft, bark and channel. Branches less than three-quarter inch in thickness may also be cleft grafted but as a rule such branches are best worked by the whip and tongue method.

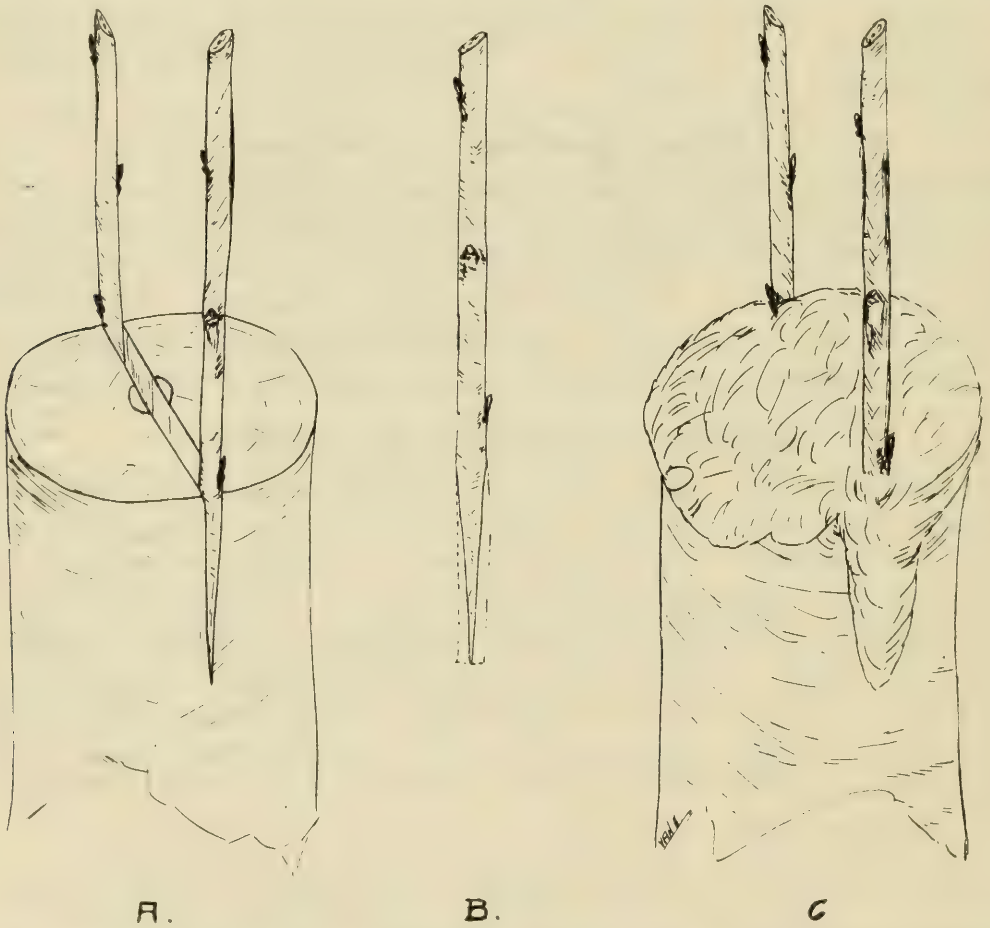
Where it is desirable to top-work large trees, the operation should be spread over a period of two or three years. From one-third to one-half of the branches (preferably the main leader and upper branches) should be grafted the first year and the remainder during the next year or the following year. If a large tree is grafted all at once the shock from the operation will be great, a large number of shoots will likely develop, which will hinder the proper growth of the scions and entail considerable labour to remove. Small and medium sized trees may be completed at one operation without any serious consequences to the tree.

Branches selected for grafting may be cut off quite near the point from which they arise, the distance depending on the size of the branch. On small trees the cut may be made eight to twelve inches out, but on large trees the cut should be farther from the centre owing to the larger size of the branch. If possible the cut should be made not farther out than four feet, but this, however, cannot always be done because of the large size of the branch. In all cases one should endeavour to select branches which will make a strong, well-built, shapely tree with a moderately low head.

In cutting long or heavy branches care should be taken to prevent splitting. This can be done by cutting, first, on the under side of the branch and then cutting from the top or by supporting the branch beyond the point where it is to be cut; or the branch may be cut off a short distance beyond the place where the scions are to be inserted and the short stub which remains can be cut at the proper place without any danger of splitting. On trees which are not too large for grafting all at once, one should, where possible, cut the branches just beyond a lateral so that the lateral will partly absorb the flow of sap and thus prevent the scion from being injured by a too abundant sap supply.

Cleft Grafting

Cleft grafting is one of the best known methods of top-working trees. In this method the branches selected for grafting are cut squarely across at the point where it is desired to place the scions. The end of the branch is then split with a grafting knife to form a cleft for holding the scions. When an upright growing branch or trunk of a tree is to be cleft grafted, the cleft may be in



A.—Stock branch with scions inserted in cleft. Note how top bud is in line with cambium contact.
B.—Scion cut to wedge shape.
C.—The completed graft with all cut surfaces thoroughly coated with wax.

any direction, but branches which grow out at an angle should be split horizontally, and not vertically as is sometimes done. The reason for this is that if the branches were split vertically and two scions were inserted one would of necessity be placed at the top of the cleft and the other would be at the bottom. In this instance the lower scion would not have equal chance with the upper one and might not grow well; but if both were placed in a horizontal cleft each would have the same conditions and both would be more likely to grow. The clefts should not be deeper than is necessary to hold the scions properly. Deep clefts do not hold the scions so firmly as shallower clefts and take longer to heal. A cleft two inches deep would be quite sufficient in most cases but, of course, it is not always possible in practice to prevent the branches from splitting deeper than is necessary to merely hold the wedge end of the scion. After the branch has been split a screw driver or the wedge-shaped portion of the grafting knife is inserted in the centre of the cleft to hold it open for the insertion of the scions.

The scions should be prepared for grafting immediately before they are to be placed on the stock. The method of preparation varies with the type of grafting used. For both cleft and bark grafting the scions are usually about four inches long and should contain from two to four buds.

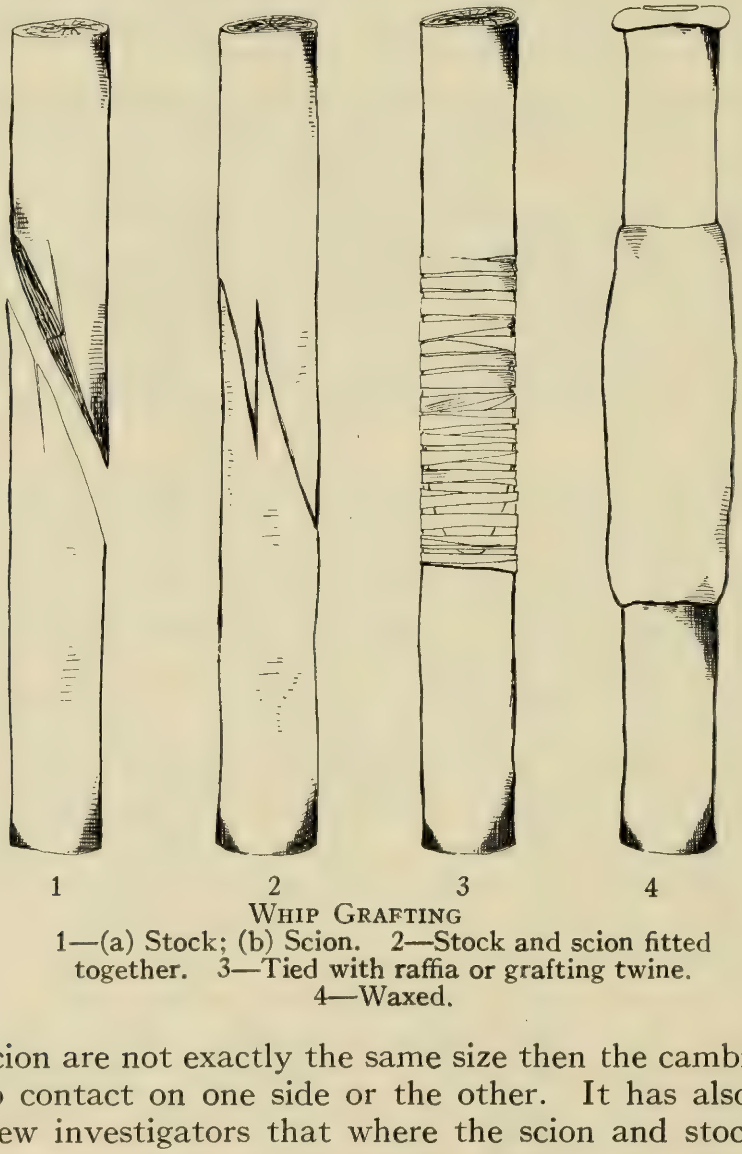
Scions for cleft grafting are prepared by making a straight sloping cut about one to one-and-a-half inches long on one side of the lower end of the scion and then making a similar cut on the other side, thus forming a long thin wedge. One side of this wedge should be slightly thicker than the other and should be made so that a bud is left just above the top and on the thicker side of the wedge.

The wedge end of the scion is then inserted in the end of the cleft in such a position that the bark of the scion crosses the bark of the stock, and the top of the wedge part of the scion is on a level with the end of the branch with the thick side outward. To make sure that the cambium layer of the scion comes in contact with the cambium layer of the stock the scion is inserted at a slight outward angle to the general direction of the branch.

When the scions have been placed, the wedge of the grafting knife or the screwdriver is withdrawn, thus allowing the branch to close on the scions and hold them firmly in position. If a large limb is to be cleft grafted a small hardwood wedge should be inserted in the centre of the cleft to prevent the stock from closing too tightly on the scion and thus interfering with a proper union. The cleft in the end and on the sides of the branch is then filled with grafting wax and the end of the branch is coated with the same material to prevent drying and to exclude disease organisms. Branches one inch in diameter require only one scion, those over one inch in diameter will require two. Large branches, for example those of four to five inches in diameter are sometimes cleft twice, the two clefts being on opposite sides, or in some cases, the branch is cross cleft. Double clefting and cross clefting are not recommended, as such branches can be more satisfactorily worked by bark grafting.

Whip Grafting

Whip grafting is employed to a considerable extent as a means of top-working small trees. In this method it is desirable to have the stock and the scion of the same, or nearly the same, size and, therefore, stocks ranging from one-quarter to one-half inch in diameter are the best for this purpose. One-year-old trees may be trunk grafted, but in the case of two-or three-year-old trees the scions should be placed on the small branches near the main fork. The stock is prepared for the scion by making a long, straight, smooth cut diagonally across the trunk or branch. The length of the cut will vary from one to two inches, depending on the size of the trunk or branch. A tongue from one-half to three-quarters of an inch deep is then made on the face of this sloping surface by inserting the knife about half way between the heart and the point of the tip, cutting diagonally across the heart. By cutting diagonally across the heart there is less danger of splitting the stock than is the case where the cut is made in the direction of the grain. In some cases the incision is made straight down with the grain. The scion is prepared in precisely the same way and should contain three or four buds, one bud being just above the top of the sloping cut. The scion is then fitted to the stock by inserting the tongue of the scion into the cleft of the stock. If the stock and scion are the same size the cambium layers will necessarily come into contact on both sides, but if the stock and the scion are not exactly the same size then the cambium layers must be brought into contact on one side or the other. It has also been observed recently by a few investigators that where the scion and stock differ in size, better results are secured in set and growth of scions when the scion is cut so that the topmost bud is on the side of best cambium contact. When the scion has been fitted to the stock the two are firmly tied together with bast, raffia or waxed string, special care being taken to have the greatest possible area of the cambium layers in contact. Wax (preferably melted wax) is then applied over the point of union. When tying the stock and scion or applying wax, care should be taken to prevent a displacement of the two as no union will take place if the cambium layers do not fit closely. After the scions start to grow they should be examined to see that the material used in wrapping the grafts



WHIP GRAFTING
1—(a) Stock; (b) Scion. 2—Stock and scion fitted together. 3—Tied with raffia or grafting twine. 4—Waxed.

is not injuring the branches by acting as a girdle at the point of union. It is advisable to cut all such tying material a few weeks after the scions begin to grow.

Bark Grafting

Bark grafting, though not so well known as cleft grafting, is a good method of top-working fruit trees. This method has several points in its favour.

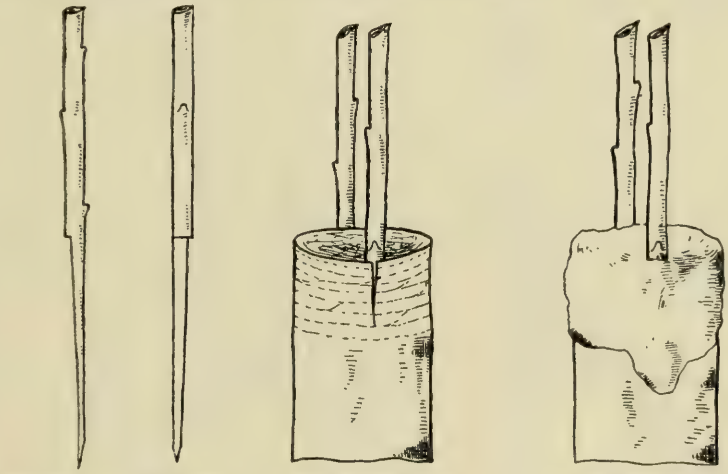
(a) A larger area of the cambium layer of the scion may be brought into contact with the cambium layer of the stock, thus increasing the likelihood of a union.

(b) It is not necessary to split the branch to receive the scions and hence a more complete and rapid healing of the stub is made possible.

(c) Trunks or branches too large for cleft grafting may be readily grafted by this method.

(d) Several scions may be inserted on medium or large sized branches, thereby multiplying the chances of success.

(e) The work can be easily and quickly done.



SIDE VIEW OF SCION CUT READY FOR GRAFTING

FRONT VIEW OF SCION CUT READY FOR GRAFTING

VIEW SHOWING SCIONS INCERTED ON STOCK AND HELD IN POSITION WITH WRAPPING.

VIEW SHOWING METHOD OF WAXING OVER INCISION AND END OF STOCK

BARK GRAFTING

In bark grafting the branch is prepared for the scions by cutting it straight across as in cleft grafting. Where it is desirable to graft the trunk or an upright growing branch, the cut should be made at a slight angle so that rain may run off readily.

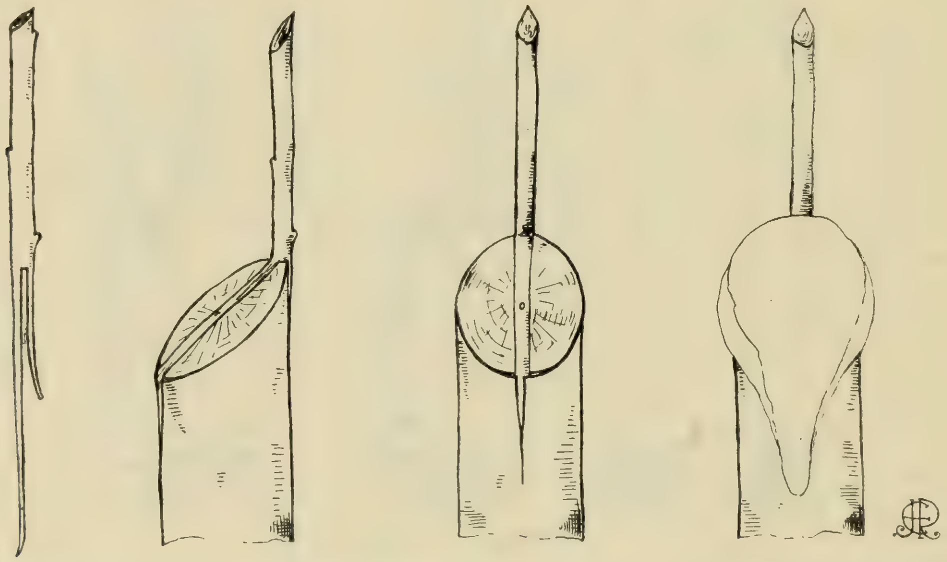
The scions for bark grafting may be prepared in various ways, but the best method is to make a straight sloping cut about two inches long at the lower end and then cut a shoulder at the top of this wedge by cutting about half way across the scion. From this point the scion is again cut to a wedge-shape, and one side of the wedge is slightly pared off just enough to expose the cambium and to make a straight surface which will closely fit against the bark when the scion is placed. A small bit of bark should also be shaved off the tip of the wedge to allow of the cambium coming in contact with the cambium of the stock.

A slit about one-and-one-half inches in length is made longitudinally in the bark of the stock. The bark on one side of the slit is then raised, and the scion is inserted by shoving the wedge down under the bark so that the straight side of the wedge closely fits against the bark which adheres to the stock. The scion is held in place with nails or small brads. Wax is then applied in liquid form with a small paint brush to the end of the stub and over the incision in the bark. The tip of the scion should also be coated with wax.

As previously stated several scions may be set in a medium or large branch. A good rule to follow in this method is to place two scions on a two-inch branch or trunk and an extra scion for each additonal inch in the diameter of the stub. Later on when these begin to crowd all but one should be cut off. In removing the extra scions one should make the cut about one-half an inch from the end of the branch thus leaving some growing tissue which will help to heal over the cut end of the branch. If sprouts grow on this short stub they should be removed.

Strap Grafting

Strap grafting is in reality a form of bark grafting. It is called strap grafting on account of the strap-like part of the scion which extends across the end of the stock branch. The branch is prepared for the scion by cutting it either squarely or obliquely across, and the end of the branch is then made smooth with a sharp knife, the edges of the bark being slightly rounded. Scions for strap grafting are longer and are more difficult to prepare than scions for bark and cleft grafting. The scion is prepared by splitting it lengthwise, the split being made so as to divide the lower section of the scion into two unequal parts, one a thin section with a bit of wood attached to the bark, and the other a thicker part containing most of the wood. The thick section is then shortened leaving a stub about two inches long. The thin strap-like piece is bent at right angles to the scion, and a cut made across the scion about two-thirds of its diameter at the point where the thin section joins the main part of the scion. From this point the short section is then cut to a wedge shape similar to the wedge made in bark grafting.



SIDE VIEW OF SCION READY FOR GRAFTING

VIEWS SHOWING METHOD OF GRAFTING SCION ON STOCK

VIEW SHOWING METHOD OF WAXING OVER INCISION AND END OF STOCK.

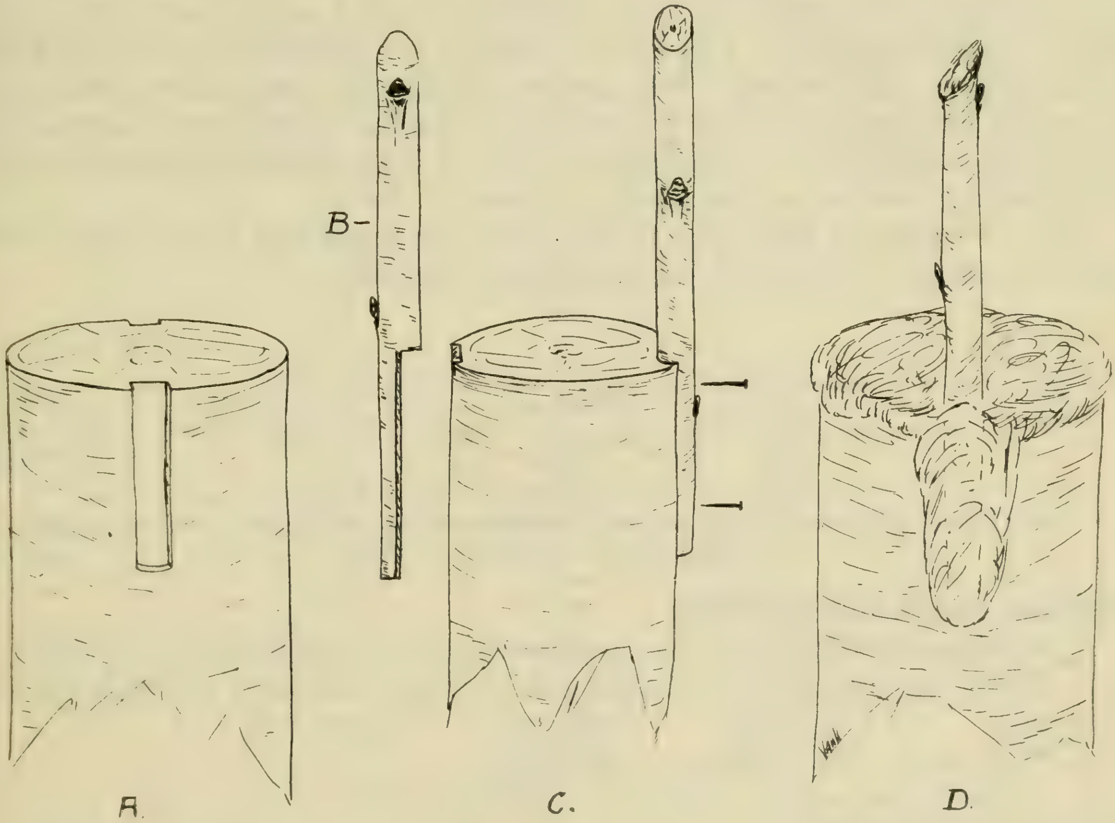
STRAP GRAFTING

A longitudinal slit is made in the bark of the stock and the corners of which are raised with a knife, and the short part of the scion is then shoved down between the bark and the wood directly beneath the slit. A channel is then made on the opposite side of the stock by cutting two slits in the bark, the slits being just far enough apart to accommodate the strap-like part of the scion. The bit of the bark between the two slits is cut off and discarded. The strap-like portion of the scion is brought across the end of the stub, laid in this channel, and fastened with brads or nails. The end of the stock and any incisions in the bark are then coated with grafting wax.

In this method of grafting the end of the branch heals over rapidly, due to the lateral growth from the strap-like portion of the scion. The disadvantages of this method are that the scions are rather difficult to prepare, and usually only one scion is put on a branch. For this reason, and partly because it is not generally known, it is not used to the same extent as bark or cleft grafting in Canada, but in Australia where this method originated it is quite popular.

Channel Grafting

The principle of this method is much the same as in bark grafting, differing in that the scions are fitted into a narrow channel made in the bark, instead of being pushed under the bark.



A.—Stock with channel cut in bark. N.B.—All bark must be removed from channel, otherwise scions will not grow.
B.—Scion prepared for placing in channel on stock. Scions should be made so that top-most bud is in direct line with cambium contact.
C.—Scion set in channel ready for nailing. Small nails at right of scion indicate points where nails are driven in. (Three-quarter inch No. 20 wire nails make a convenient size for fastening scions in place.)
D.—Cut surfaces coated with wax.

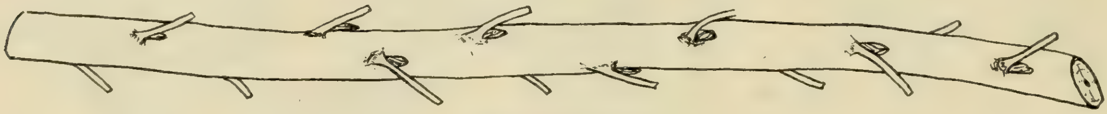
The scion is prepared by reducing the diameter of the lower end to one-half the original thickness, for a length of one and one-half to three inches. The edges of this reduced section are then pared off very lightly, just enough to expose the cambium. This paring must be done very carefully as it is rather easy to take off too much tissue and thus leave the cambium in a position where it would be impossible to secure contact with the cambium of the stock. After the scion has been prepared a channel is cut in the bark of the stock at the end, the precise width and length of the reduced section of the scion. The scion is then fitted into this channel and fastened in place with brads or small nails, after which wax is applied over the points of contact and on the end of the stub.

Budding

Fruit trees which are too small for cleft or bark grafting or which are difficult to work by ordinary methods of grafting may be top-worked by budding. This method for small trees is considered by some authorities to be superior to whip grafting, as any buds which fail to grow may be replaced by other buds inserted in fresh bark near the point where the first bud was set. The operation can be easily done and, if care is exercised, good results may be secured. When it is desired to top-work peach, sweet cherry and apricot trees the work is best done by budding as previously noted.

The method of procedure for these fruits varies somewhat with the size and condition of the trees. Young trees with branches of one-third to two inches in diameter may be worked by budding directly on the branches as they are, but older trees with larger branches should be forced into a vigorous condition of growth before budding. This can be done by a combination of severe pruning, soil cultivation and the use of nitrogenous fertilizers. In heading back for this purpose cut off from one-third to one-half of the top growth and if possible, cut just beyond and close to a good lateral. Large cuts should be coated over with liquid grafting wax or white paint to prevent decay.

After a vigorous new growth has been obtained the new shoots may be budded by either of the methods described hereunder.



BUD STICK.
A small branch of the current season's growth with the leaves cut off so as to leave a part of the leaf-stock on stick.

Materials Used for Budding

1. A sharp budding knife for making the cuts and detaching the buds.
2. Raffia for wrapping the branches or trunk at points where buds are to be inserted.
3. Bud sticks from desired varieties.
4. A basket or pail to carry bud sticks in.

Methods of Budding

There are various methods of budding but those most widely known are the shield bud and plate bud. The details of each are set forth under their respective headings.

Shield Budding

(a) From trees of the variety which it is desired to propagate, cut a sufficient quantity of well developed healthy branches of the current season's growth. These should be about one quarter of an inch in diameter at the base.

(b) Cut from the lower and upper ends about one quarter of the shoot, leaving it approximately one half its original length.

(c) Cut off the leaves, taking care to leave about one-half inch of the leaf stalk to facilitate handling of the buds.

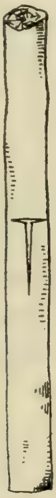
(d) Wrap bud sticks in damp sacking to prevent drying out.

(e) Select a smooth place on the trunk of the tree or on the upper surface of the branches chosen for budding and make a "T" shaped cut in the bark.

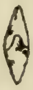
(f) Cut from the bud stick a medium-sized bud. In cutting the bud, the knife should be inserted in the bud stick from one-half to three-quarter inch below the bud and drawn upward underneath the bud until the edge is about one-quarter inch above the bud, then the edge is turned at a slight angle and brought out about three-quarters of an inch above the bud. The cut should be made deep enough to include a small bit of wood. This bit of wood is sometimes discarded but is more often left on the bud.

(g) Gently raise the edges of the longitudinal slit with the wedge end of the budding knife and insert the bud by shoving it down underneath the two flaps of bark until the top of the bud is slightly below the cross cut. The projecting tip of bark is then cut off even with the cross cut and the bud pressed down. In some cases the point of bark is cut off before inserting the bud. In either case, enough bark should be left above the bud to allow the raffia to be bound over it between the bud and the cross cut.

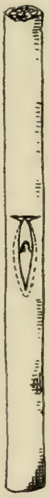
(h) Wrap the stock above and below the bud with raffia or waxed cotton, taking care not to cover the bud in so doing. The raffia should be tight enough to hold the flaps of bark firmly in place over the bud, but should not be too tight as it may interfere with the growth of the bud. The bud should unite with the stock in from two to three weeks, and after that time, the string or raffia should be cut to prevent injury to the bud. In topworking the sweet cherry by budding



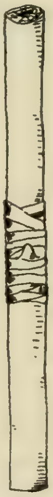
VIEW SHOWING CUT IN STOCK



THE BUD



VIEW OF BUD IN POSITION READY FOR TYING UP



VIEW OF BUD TIED UP WITH RAFFIA

it has been found that better results are secured when waxed cotton is used to tie the buds in place. Also it has been observed that the buds will come through the winter in better condition if the wrapping material is left on over winter. The small leaf stalk will fall off if a union takes place, but if the operation has not been successful, it will continue to adhere to the bud. Early next spring the branches or seedling trunk should be cut off a few inches beyond where the bud has been inserted. This stub beyond the bud will serve as a support to which the growing shoot may be tied to prevent it blowing about during the first season of growth. Late in the summer of the first year's growth, or in the second spring, after the bud has grown for one season, the stub should be cut off just above where the bud has been placed.

Small trees up to one inch in diameter may be top-worked by inserting four or five buds on the trunk at intervals of five or six inches, each bud being placed on a different side of the tree, where it is desired to have a branch appear. In this way, it is possible to have a strongly built and well balanced tree when the buds develop into branches or have a high or low headed tree by placing the buds high or low on the trunk. After the buds begin to grow the trunk should be cut off just above the topmost bud.

The Plate Bud

The plate bud, though not used so widely as the shield bud, is nevertheless a good method. It is easier to do than the shield bud, and for certain species of trees such as the sweet cherry, gives better results in nursery work. It can also be done later in the season than the shield bud.

For this method branches of one-quarter to one inch in diameter are quite satisfactory. The branch is prepared for the bud by removing a thin strip of bark one and one-half to two inches long on the side or upper surface as desired. This can be easily done by making a downward slicing cut of sufficient depth to expose the wood to a width of one-quarter inch. The loose strip of bark is not removed entirely, but is cut off about one-half inch above the lower end of the slicing cut. The bud is then cut from the bud stick in almost the same manner as the shield bud, the only difference being in the length of the bud strip. For the plate bud the strip should be the same length as the exposed section on the stock branch. In removing the bud strip the cut should be made deep enough to include a very thin slice of wood, particularly under the bud. The bud is then placed in position by inserting the basal end underneath the loose flap of bark on the stock and aligning the edges as closely as possible with the edges of the exposed section on the stock. In cases where this exposed area is noticeably wider than the bud strip care should be taken to align the bud on one side or to place it diagonally across so as to get cambium contact on both sides. After the bud has been placed it is wrapped in position with long narrow strips of waxed cotton. In tying the buds start just below the bottom of the bud and give a double turn around the branch with the material and then continue upward slightly lapping the edge of the material with each turn until the bud strip has been completely covered. The end of the wrapping material should be fastened with a tack or by inserting it under the last turn and pulling tightly. In tying the buds by this or any other method care should be taken to leave the bud itself exposed.

The plate bud is used chiefly for propagating the cherry in nurseries, and to a lesser extent as a means of topworking undesirable trees. In topworking the sweet cherry, much better results are secured when the buds are coated with a thin film of warm parawax. This material should be applied when warm enough to flow easily so that a thin coating will form over the bud and any exposed tissue near the bud. Parawax assists materially in that it prevents desiccation or drying out.

Care of Top-Worked Trees

The pruning of grafted trees is a feature that requires proper consideration if the best results are to be obtained. Branches which have been grafted usually throw out numerous shoots which if allowed to remain will interfere with the growth of the grafts. Most of these shoots should be removed, particularly those near the grafts so that the grafts will have the best conditions for making a strong growth. In the spring of the second year after grafting remove such branches as were left to absorb excess sap flow or to carry on growth processes. Remove also any shoots which may have appeared during the previous summer.

The pruning of the new top from this time on until the grafts begin to bear should be done in much the same way as is now recommended for young non-bearing trees. That is to say, very little pruning should be given. All that is necessary is to cut out sucker growth from the stock and to remove the least desirable of crowding branches of the scion variety. The reason for recommending light pruning is that experimental work shows conclusively that the less pruning a young non-bearing fruit tree receives the faster it will grow and the sooner it will come into bearing.

In the grafting over of most trees the majority of branches require two or more scions. In such cases, if more than one grows, all should be left until they begin to crowd each other. When this condition is noted the least desirable should be cut out, leaving one good strong graft on each stub. The leaving of more than one graft on a stub until a crowded condition appears, is recommended because of the more rapid healing over of the stub which takes place when two grafts are left. When these crowding grafts are cut out the cut should be made slightly beyond the end of the stub so that some of the basal part of the graft remains as living tissue for a protection to the original cut.

(2) BRIDGE GRAFTING

Many valuable fruit trees are lost from time to time through damage being done to the bark on the lower part of the trunks by various agencies, such as rodents, insects, plant diseases, mechanical injury or climatic influences.

Examples of Trunk Injury

(a) Rodents. Mice or rabbits often partly or completely girdle the trunks of trees at or near the ground during the winter.

(b) Insects. Bark borers sometimes girdle trees by tunnelling the bark, thus checking growth or killing the bark outright.

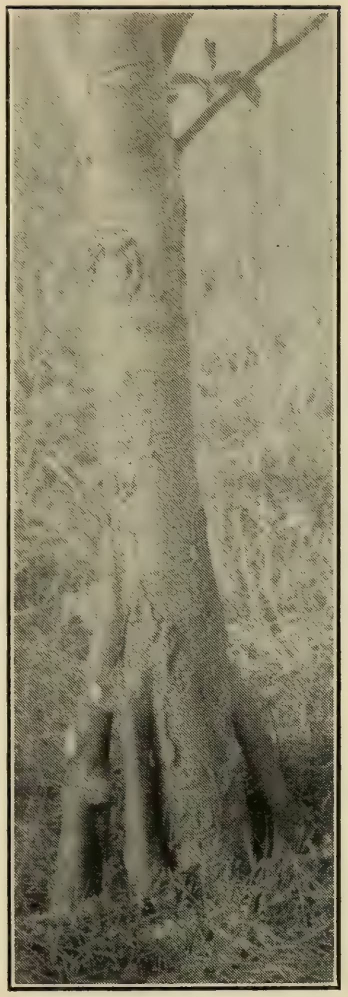
(c) Disease. Bacterial blight of the pear and apple occasionally destroys part of the bark on the trunks of trees while the bark near the ground or on the limbs above may be uninjured.

(d) Winter Injury. Certain varieties of apple such as the King, Ontario and Grimes Golden are subject to a form of winter injury known as collar or crown rot. The bark just above the crown or collar may be partly or wholly destroyed by the action of low temperatures. Another form of winter injury is known as "Bark Splitting." In severe cases, the bark will split vertically in several places, and it may also be separated from the wood for several inches up and down the trunk.

(e) Mechanical Injury. The bark on fruit trees is occasionally damaged through carelessness in handling tools and implements.

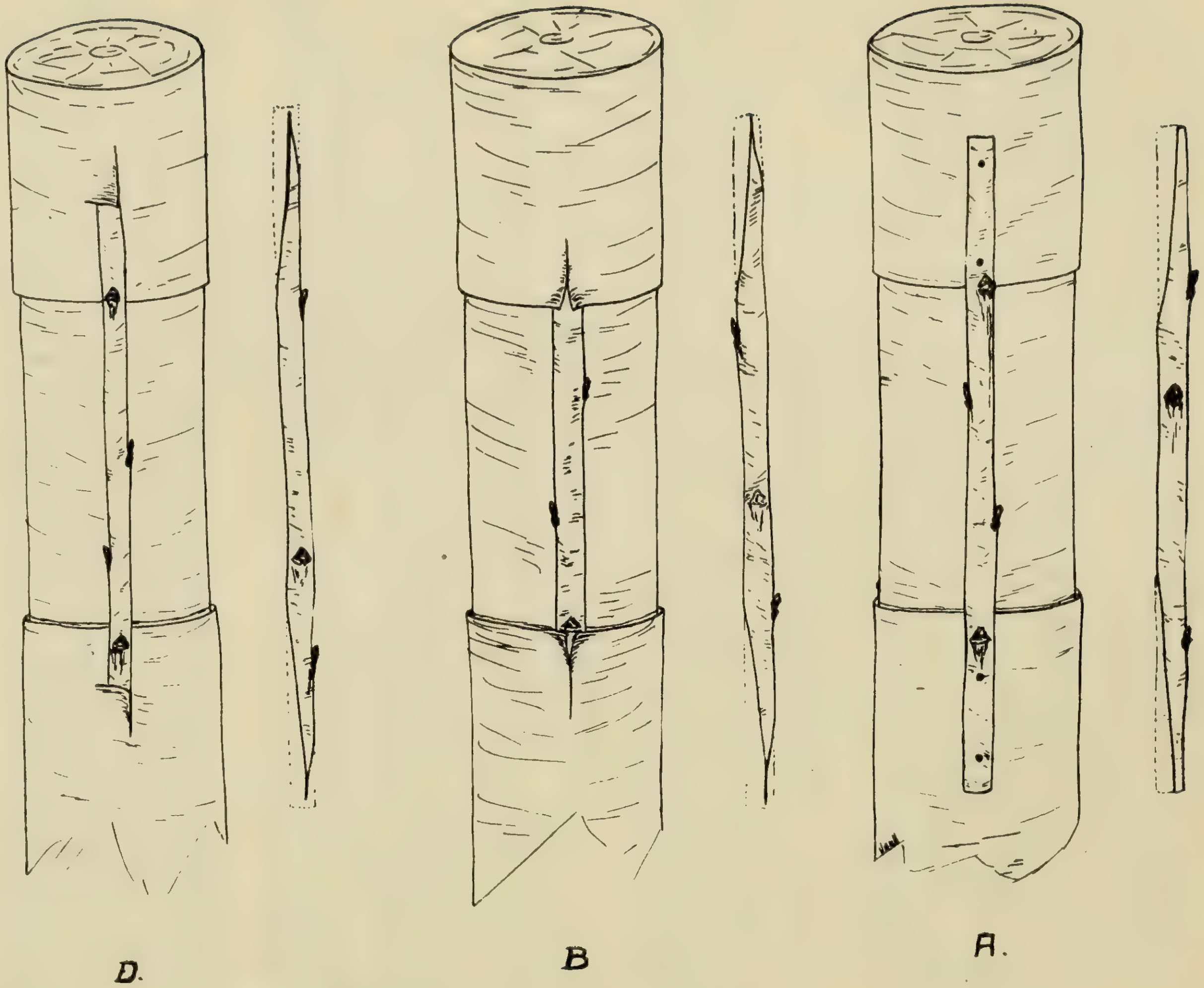
Trees injured by any of the agencies noted above may be saved by bridge grafting. The term bridge grafting is used in reference to an application of the art of grafting in which a bridge of living tissue is made across the injured areas, thus permitting of a continuation of growth processes. There are several ways in which bridging may be accomplished, each one of which will give good results if properly done.

Just before the bridging is to be done, both edges of the injured area should be cut back to the uninjured healthy bark and the exposed area cleaned of bits of dead tissue. In doing this cleaning care should be taken to leave every bit of healthy bark even though it may occur as an island in the girdled area, or may necessitate leaving the girdle with an uneven margin. It should not be forgotten that any living tissue on the tree is better, for a while at least, than that which is put on by artificial means.



C.

C.—Showing how sprouts growing from base of tree may be used as scions. This is one of the best methods.



Bridge Grafting.

Drawings show various methods of preparing and inserting scions. All points of contact between stock and scions and all exposed wood surface on stock must be coated with melted wax.

Directions for Bridge Grafting

METHOD A. The Channel Bridge—This method receives its name from the fact that the scions are set in channels made in the bark above and below the girdle. Scions for this as well as other methods should be made from strong well-grown shoots of the previous season's growth such as are found at the terminals of vigorous growing trees, or what is even better, sucker growth from the centre of the tree. Suckers from the base of the girdled tree itself also make the very best of bridges as they already have one point of contact and should therefore be used wherever they occur.

The scions for the channel bridge are prepared by reducing the diameter of the upper and lower ends for a length of two to three inches to one-half their original thickness. The edges of these reduced sections are then very lightly pared to expose the cambium. This must be carefully done as it is easy to take off too much tissue and thereby place the cambium in a position where it could not come in contact with the cambium on the stock. Channels the exact width and length of the prepared section of the scions should then be cut in the bark above and below the injured area. This is best accomplished by holding the prepared scion against the trunk and outlining its position thereon. The scion is then laid aside and the channel cut in the bark following the guide lines made as just described.

In making this channel it is necessary to remove every part of the bark down to the wood. This may be easily done with a narrow chisel or a small screw driver with a sharp blade. If any bark were to be left in the bottom of the channel it would prevent the very necessary cambium contact between stock and scion.

The scions are then fitted in the channels, special care being taken to have the edges of the prepared sections fit exactly in the corners of the channel. If the channel has inadvertantly been cut too wide the scion should be crowded on one side so as to be sure of cambium contact at one point at least. When the scions are placed they are fastened in position with small nails or brads. Wax is then applied over the points of contact and on all exposed wood surfaces.

METHOD B. The scions are cut to a wedge shape at both ends by making a diagonal cut one and one-half to two inches long on one side with a very short sloping cut on the opposite side. Vertical incisions about one and one-half inches long are made in the bark above and below the injury at the points where the scions are to be inserted and the bark is raised by inserting a knife blade between the bark and the wood. The scion is then placed in position by inserting the lower end under the slit bark at the bottom of the girdle and the upper end under the slit at the top. As each scion is placed it should be fastened in position with a nail or brad as in channel grafting. Scions should be cut long enough to allow of a slight outward bow being formed when placed in position.

METHOD C. Occasionally trees are found where the injured area is too large to permit of the use of scions as described above or in some cases the girdle extends below the ground to the roots. Where extensive injuries of this kind occur it is questionable whether bridge grafting is advisable in all cases. In some cases, however, it may be worth while saving the tree. This may be done by planting young trees of the same kind but not necessarily of the same variety, near the base of the affected tree. These trees are set in a ring around the tree and at a slight distance from the base. After the little trees have been planted the tops are cut off leaving a trunk of sufficient length to permit of a good contact above the girdle. The upper end of these little trunks are prepared and laid in channels precisely as described for the channel bridge.

Method D. A T-shaped cut is made in the bark about an inch above and below the girdle, the upper one being in the form of an inverted "T," thus ⊥. The scions are cut to a wedge shape at both ends as described in Method "B," and placed in position by shoving the ends underneath the raised corners of the "T" shaped cuts. Brads or small nails are then used to fasten the scions in place.

In all operations of bridge grafting, it is desirable to space the scions as closely as possible along the margins of the girdle without unduly interfering with the bark. The channel method has an advantage in that it permits of closer spacing than some of the other methods. In this method scions may be placed as closely as one inch apart if the work is carefully done, but with other methods which involve lifting the bark, a wider spacing is necessary to avoid undue interference with the margins of the girdle. A one-inch spacing on a four-inch tree would require from ten to twelve scions, a number that might seem unduly large particularly where many trees were to be bridged. In the case of large numbers of trees being injured, it would be better to space the scions farther apart as a matter of expediency, and then fill in the spaces the following year with more scions.

Where good scions have been used and a union takes place, shoots often grow on these scions. This growth should be left for the first season at least and possibly for the second year as well, because of its beneficial affect on the diameter growth of the scion. Observations made in this Province show conclusively that scions with shoots will grow twice as fast as those without any. After the scions have become well established the shoots should be removed.

In many cases of girdling the injury extends only part of the way around the trunk. Where the injured area occurs on small trees and does not involve more than one-third the circumference, it may not be necessary to bridge. In such instances, the exposed area should be coated with good hot wax as a means of preserving the wood, and left to heal over of itself.

Where the trees have been completely girdled by rabbits, mice or other agencies, and are not more than two or three years old, it might be better to dig them up and replace by new trees. If the injury is some distance above the crown the tree may be saved by sawing off the trunk, and cleft, or bark grafting with the desired variety; or one may dispense with grafting and take a chance on good, strong sprouts developing on the uninjured part above the original bud or graft. The best one of these sprouts should be selected for the new trunk.

The old saying that prevention is better than cure is especially applicable to the girdling of fruit trees. All the injury usually done by mice and most of that done by rabbits may be more easily prevented than repaired. For preventive measures the reader is referred to Ontario Department of Agriculture, Bulletin 323, "The Apple in Ontario."

(3) PROPAGATION

Fruit and ornamental trees or shrubs which cannot be economically propagated by other means can be quickly reproduced by various forms of grafting. Whip grafting on seedling roots and budding on seedling trunks are the methods most extensively used in the propagation of fruit trees.

The propagation of fruit trees on a commercial basis is a special business which requires expert knowledge and for this reason it is not usually undertaken by the fruit grower, but is carried on by nurserymen. It usually will not pay the grower to propagate his own fruit trees, but if one so desires, it may be done. Ontario fruits are propagated by budding or root grafting on suitable stocks.

The following table will show the methods used for the tree fruits grown in Ontario:—

Kinds of Fruit	How Propagated	When Propagated	Stock Used	Stocks Produced from
Apples				
(a) Standard	1. Root Grafting 2. Budding	Jan.—Feb. August	French or American grown seedlings or Siberian crab	Seeds
(b) Semi-dwarf . . .	1. Root Grafting 2. Budding	Jan.—Feb. August	Doucin apple	Mound layers
(c) Dwarf	1. Root Grafting 2. Budding	Jan.—Feb. August	Paradise apple	“ “
Pears				
(a) Standard	1. Root Grafting 2. Budding	Jan.—Feb. August	French grown Seedlings, Kieffer pear	Seeds “
(b) Dwarf	1. Root Grafting 2. Budding	Jan.—Feb. August	Angiers quince	Mound layers
Plums				
(a) European	1. Budding	August	Myrobolan plum	Pits
(b) Japanese	1. Budding	“	Mariana “	“
(c) Americana	1. Budding	“	Americana “	“
Cherry				
(a) Sweet	1. Budding	August	Mazzard Mahaleb	Pits
(b) Sour	1. Budding	“	“	“
Peach	1. Budding	August	Seedling peach	Pits
Quince	1. Budding	August	Angiers quince Common quince	Mound layers Cuttings or seed

Budding

Budding is a common method of propagating fruit trees, especially peach, cherry and plum. The style generally used is shield budding, so-called, because the bud when properly cut from the bud stock resembles a shield. Young seedling trees are used as stocks on which to bud the desired varieties. The stocks are prepared for budding by stripping leaves from the trunk to four inches above the ground a few days before budding is to be done. This is done to give a clear smooth place in which to insert the new bud and to prevent the old buds interfering with the growth of the new bud after it has been placed. The method of procedure for this purpose is the same as described in top-working the trunks or branches of small trees by budding. The bud, however, should be placed on the north side of the seedling tree, not more than three inches above the surface of the ground. When the bud has been set, it is wrapped with raffia to hold it in place. In two or three weeks, the bud will have formed a union with the stock after which the raffia is removed. The stock is cut off above the bud early the following spring. In a year or two the budded trees are ready for planting.

Root Grafting

This method of propagating fruit trees is extensively used in Canada for apples. The roots which are used as stocks are usually obtained from France, and occasionally from the United States, but may be produced by sowing seeds of standard sorts or of the Siberian Crab (Pyrus baccata). Seedling trees for root grafting should be dug up in the fall and heeled in, in sand in a cool cellar until wanted for grafting. During January or February the trees are taken out and root grafted by the whip and tongue method. A small section of root three to four inches long, is used as stock or a whole root may be used. The method of cutting and fitting the stock and the scion is the same as described under the section on top-working by whip grafting. The stock and the scion are then wrapped with string and coated with wax at the point of union after which they are set away until spring. By this time a union will have taken place, after which the string is cut, and the grafts are planted in a nursery row. If own-rooted trees are desired, these may be produced by using scions from eight to twelve inches long and planting deep, with only one or two buds above the surface of the ground. The scions of some varieties will produce roots and in the cases of hardier sorts, the result is a tree which suffers less from root killing.

Hardy Fruit Stocks

The problem of securing hardy root stocks for propagation purposes, or hardy varieties on which to top-work other desirable and less hardy varieties, is one of great importance to fruit growers living in the northern apple growing regions of America. This problem has recently come in for consideration by several experiment stations in the United States and some valuable initial work has already been done. Much more remains to be done along this line, and many are of the opinion that a comprehensive line of investigational and research work on the fruit stock problem should be undertaken in Ontario. The writer had the privilege of spending one year in making a special study of this problem while acting as research assistant in the Pomology section of the Iowa State College. Some interesting and valuable data were obtained by original investigational work and from correspondence with fruit growers and experiment station officers in various parts of Canada and the United States. A summary of these data show fairly conclusively that some good commercial varieties of apples which are not entirely hardy can be more satisfactorily grown by top-grafting on hardy vigorous stocks planted for the purpose.

The varieties which were most frequently mentioned by correspondents as desirable stocks are as follows: (1) Hibernal, (2) Virginia Crab, (3) Tolman Sweet. The above-named varieties appear to have given the best satisfaction over a wider range of territory than any other varieties listed. In the Middle Western States, the Virginia Crab and the Hibernal appear to be the most satisfactory stocks for the three leading commercial varieties, e.g., Grimes, Jonathan and Delicious, and in the Eastern States and Ontario, the Tolman Sweet appears to be the favourite for working with such varieties as Spy, King, Cayuga Red Streak and Baldwin. In the colder parts of Ontario, e.g., St. Joseph Island, the Hibernal and Darts Crab are said to be the best stocks for the varieties grown there.

The common nursery practice of using French crab roots for propagation purposes is open to criticism, largely because it is believed by many that such stocks are lacking in hardiness. There is some evidence to show that own-rooted trees of hardy varieties are much more desirable on account of the greater hardiness which is secured. Some economical system should be devised of securing hardy root stocks for propagation purposes or of getting hardy varieties on their own roots to be grown either as stocks for re-working or for fruit. This important work should be undertaken by our experiment stations, and when brought to a successful stage should be adopted by our nurserymen.

GRAFTING MATERIALS

Grafting Waxes

The operation of waxing is an important factor in securing a good stand of scions. Wax when properly made and applied protects the scions against desiccation or drying out and thus favours growth conditions.

There are various formulae for the preparation of wax, two of which are given herewith. These are referred to as "hand wax" and "brush wax," because of the method of application. The hand wax, or hard wax as it is sometimes called, is applied with the hands in a semi-plastic condition while the brush wax is applied in a liquid condition with a brush.

1. Hand Wax or Hard Wax formula.

Resin (crushed)	4 parts by weight
Beeswax	2 " " "
Tallow	1 " " "

This wax is prepared as follows. Place the resin in a kettle and melt over a slow fire. Add the beeswax and when this has melted add the tallow. When all is melted pour the mixture into a pail of cold water. The hands should then be greased and the wax worked until it becomes pliable and of a uniform consistency. For convenience in carrying, it may be moulded into balls weighing about a pound and then wrapped in oiled paper.

When ready to apply work with the hands until the wax is soft enough to permit of it being forced into the clefts and spread over the cut ends of the grafted branches.

2. Brush Wax.

A brush wax is now being used which has superseded the hard wax in some sections. This wax retains its good qualities longer than any of the hand waxes and can be more quickly and easily applied. In addition it is somewhat cheaper and will go farther than the hand wax described above. This wax is made as follows:

Resin	5 lbs.
Beeswax	1 lb.
Linseed oil (raw)	¼ to ½ pint
Lampblack or powdered charcoal	½ lb.

Melt the resin, add beeswax and when this has melted pour in the oil. Remove from the fire and stir in the lampblack, a little at a time to avoid boiling over. This mixture is highly inflammable and should be carefully watched to prevent boiling over while the cooking is going on.

Where only a small amount of wax is needed it may be prepared and used as soon as cool enough to apply without injury to the scions. In cases where a considerable amount of grafting is to be done, it is best to prepare a good supply of wax in advance. This may be done conveniently by melting the wax as described above and pouring it into shallow pans to a depth of about an inch for cooling. After the wax has hardened it may be removed from the pans by striking a sharp blow on the bottom. The wax can then be broken up into sections and melted as desired.

Parawax

In recent years parawax has been used as a substitute for the ordinary forms of grafting wax. In the majority of cases it has given very good results and in a few instances has given excellent satisfaction. Parawax cannot be applied in a semi-plastic form and therefore has to be melted before using. It should be applied when hot enough to flow easily but not hot enough to injure the buds or bark. The best temperature for application has not yet been determined, but it is believed that a temperature of 170° F. is not too high.

Grafting Tools

The tools required for grafting are easy to obtain and in fact are found on most farms. The chief requirements are as follows.

1. Saw.—A single edge pruning saw with fine teeth or a medium fine hand saw are quite satisfactory for cutting off the branches. All saws should be kept very sharp, so as to make smooth clean cuts.

2. Grafting Knife.—There are several good grafting knives on the market, any one of which will give satisfaction. The principal requirement of a grafting knife is that it shall be very sharp and have a strong blade. Much of the success in grafting depends upon bringing together clean straight cut surfaces of stock and scion and this condition can be obtained only where sharp knives are used. A good sharp pocket knife may be used as a substitute for a grafting knife.

3. Grafting Chisel or Butcher Knife.—A grafting chisel is used to split the branches for cleft grafting. Chisels may be bought from orchard supply houses or made by a blacksmith. A strong butcher knife may be used for splitting the branches with very good success. Indeed a butcher knife does not split the wood fibres as does a grafting chisel, and thus makes a cleaner smoother cut. When a butcher knife is used it will be necessary to use a screw driver to hold open the cleft. As a matter of fact a screw driver is really better than a grafting chisel, because it can be more easily used to adjust the width of the cleft and thus permits of a better fitting of scions.

4. Mallet or Hammer.—In making clefts a mallet or hammer is necessary to drive in the chisel or butcher knife. A section of a branch about fifteen inches long and from two to three inches thick makes a good substitute for either of the above.

5. Brushes.—A small paint brush about one inch wide is all that is necessary for applying the wax. These brushes can usually be purchased for a small amount and last just as long as a more expensive brush. In applying wax care should be taken to keep the brush out of the pot when not in use. If the brush is allowed to stand in the waxing pot it will destroy the bristles in a short time.

6. Waxing Pot.—Where brush wax is used it will be necessary to keep it quite warm while applying. For this purpose, a cheap but serviceable waxing pot can be easily made by taking an old kerosene can, cutting out the top and making eight small holes about five inches from the top, two on each side about four inches apart, and running wires through these holes so that the wires cross each other and form a frame to support the vessel containing the wax. A hole is cut in the side and an alcohol lamp or a kerosene lamp is set in the bottom to provide heat to keep the wax warm and soft. If desirable, one may purchase a special waxing pot or grafting lantern. One of the best of these lanterns, known as the Merribrooke Heater, is now sold by some of the orchard supply houses.

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Insects Attacking Vegetables

LAWSON CAESAR, Provincial Entomologist

INTRODUCTION

Any person who has to combat insect pests can do so intelligently only if he keeps in mind the following things:

1. Most insects, as all beetles, moths and two-winged flies, pass through four stages: egg, larva, pupa, and adult. For instance, in the case of the house-fly there are the little white eggs, laid usually in fresh horse manure. These hatch into tiny, white maggots which feed on the juices of the manure until full-grown; at which time they are about half-an-inch in length. Then these change into pupae, which are like very large, plump grains of wheat but are brown or reddish brown in colour. These a few days later change into adults or winged flies, thus completing the life cycle.

During the pupal stage insects do not feed but remain inactive while the internal changes, which transform them into adults, are taking place.

2. Other insects, as grasshoppers, plant or leaf bugs, leaf-hoppers, scales and aphids, instead of passing through the above four stages in their life cycle pass through only three: egg, nymph or larva, and adult. Hence in these insects there is no pupal stage. In their case the larvae are usually called nymphs. Most nymphs resemble closely the adults except that they have no wings.

Aphids during the summer are an exception to the above rule in that they lay no eggs but give birth to living young. In late autumn, however, they do lay eggs and this is the stage in which they winter in the open.

3. For our purpose all insects may be divided into two great classes:

(*a*) Those having biting mouthparts.
(*b*) Those having piercing and sucking mouthparts.

These two classes may be distinguished from each other easily by observing how they feed or the effect of their feeding. The biting insect always eats pieces out of the plant, leaving holes or jagged margins. The sucking insect never does this but merely punctures the surface of the plant with its fine, sharp, needle-like beak and then sucks the juices up from the interior. The injury to the plant in this case comes from the loss of its juice or sap and sometimes also from a poison injected into the tissues by the insect when feeding.

4. Biting insects may in most cases be combated by spraying or dusting the plants on which they feed with a poison, such as arsenate of lead, arsenate

of lime, or Paris green. These poisons are often called stomach poisons, because the insect in feeding takes them into its stomach and is thereby poisoned.

5. Sucking insects cannot be killed by stomach poisons, because they feed only on the juices drawn from beneath the surface of the plant, and so cannot get the poisons into their bodies. They may be combated by contact poisons; that is, by hitting them with a spray or dust that kills them by contact. Such poisons are nicotine sulphate 40 per cent., lubricating oil emulsion, soap sprays, nicotine dust, pyrethrum powder and corrosive sublimate. Remember that to kill a sucking insect the poison must hit it.

6. All larvae and nymphs are more easily killed when young and small than when full grown or nearly so; hence it is usually wise to spray injurious insects as soon as possible after the eggs have hatched.

7. Thoroughness of application is very important; for, if a plant is only half covered with the spray, sufficient insects will often escape destruction to continue breeding and cause much loss.

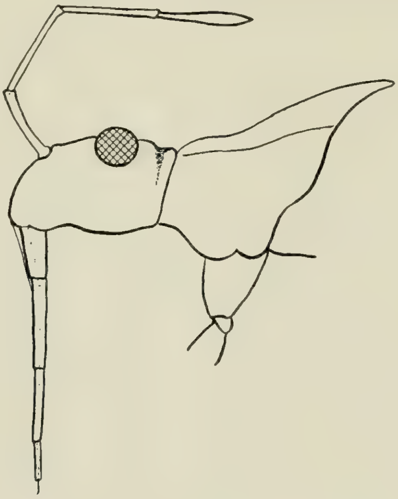

Fig. 1.—Head of sucking insect, showing long, slender beak and fine, needle-like lance, which pierces through the surface of the leaf or plant.
(R. Ozburn.)

8. Since many pests winter over as eggs, larvae, pupae or adults on plants left in the field or under rubbish or in weedy or grassy places, it is often a great help to make a practice in the fall of cleaning off all the rubbish and ploughing under or burning all the crop remnants, and in the spring burning over early all weedy and grassy places before the insects become active.

Stomach Poisons

Arsenate of Lead.—This is white in colour and is sold almost exclusively in the powder form now. It is generally used at the strength of one-and-a-half pounds to forty gallons of water or of Bordeaux mixture. Against some insects, however, as potato bugs, it is necessary to double or nearly double the strength. Arsenate of lead is the only safe arsenical poison to use with water alone on delicate foliage. It remains well in suspension and adheres excellently to the surface of the leaf. Its main defects are that it is a slow killer and rather expensive.

Arsenate of Lime (Calcium arsenate).—This also is a white powder and looks exactly like arsenate of lead but is much stronger, one pound being equivalent to one-and-a-half pounds of the arsenate of lead. It remains in suspension and adheres to the plants almost as well as the other poison and in addition costs only a little more than half as much per pound. Its chief defect is a tendency to burn the foliage of tender plants, if used with water alone. With Bordeaux mixture, however, it is safe. Potato, cabbage, and cauliflower foliage is hardy; so this is the cheapest poison to use on these plants either as a spray or as a dust.

Paris Green.—This is a green powder commonly used at the strength of one-half to one pound to forty gallons of water or of Bordeaux mixture. On potatoes the strength is usually doubled. Its chief merit is that it kills quickly. The main defects are that it does not remain in suspension at all well and therefore washes off usually with the first heavy rain; that it is inclined to burn when used with water, though safe with Bordeaux mixture; and that it is expensive.

Sodium Fluosilicate.—This is a fine white powder and is used as a dust but is usually diluted first with from five to nine times its own bulk of hydrated lime or gypsum. It has the advantage that on some insects it is both a stomach and a contact poison. In poison baits for grasshoppers and cutworms it is used at the same strength as Paris green and is said to be equally effective. Up to the present time it is not readily available, but as it is cheap and easily manufactured it may soon be procured more readily. It is not nearly so safe as arsenate of lead and may burn some kinds of plants though others are uninjured.

Derris.—This is a light, brown powder made from the roots of certain shrubs grown in the far east, especially in the Malay peninsula. It is supposed to be both a contact and stomach poison and when used as a dust is usually diluted with air-slaked lime or hydrated lime or gypsum in the proportions of about one part by bulk to twenty or even forty parts of the diluent. As a spray it is quite harmless to foliage even with water alone. It is a good insecticide against a considerable number of insects but not against all. Unfortunately it is even more difficult to secure than sodium fluosilicate, though it will likely be put on the market in the comparatively near future.

CONTACT POISONS

Nicotine Sulphate 40 per cent.—This is a concentrated extract of tobacco containing 40 per cent. of nicotine. It is commonly used at the strength of about one pint to 100 gallons of water. The addition of two or three pounds of soap dissolved in boiling water adds to its killing power, chiefly by causing it to spread more uniformly over the surface of the insect. It can be and often is used as a dust when mixed with hydrated lime. As a dust the most common strength is five pounds of the nicotine sulphate to 95 pounds of hydrated lime.

Nicotine sulphate is an excellent insecticide against aphids, leaf hoppers and some other small insects, especially if applied as a dust on a calm, hot day. Its drawback is its high cost.

Lubricating Oil Emulsion.—This is used by vegetable growers, chiefly against the onion maggot. The methods of making it up and using it are described in the account of this maggot given under Onion Insects.

Soap Washes.—A soap mixture made from one pound of laundry soap, or better, fish oil or whale oil soap, in five or six gallons of rain water will kill most small sucking insects, such as aphids. The soap is first dissolved in boiling water. Soap washes are very likely to injure the foliage, especially tender foliage. They should therefore either be used only on very hardy foliage, such as that of cabbage, or, if used on other plants, as garden peas, be washed off with water about an hour after applying.

Pyrethrum Powder.—This is a light brown powder made from the flowers of the pyrethrum plant. It is too expensive to be used on any large scale. At a strength of one ounce to one or one-and-a-half gallons of water it is very effective against cabbage worms. It is not poisonous to human beings.

Corrosive Sublimate.—This is a very heavy substance purchased usually in the form of a powder. It is a deadly poison to man and livestock and is used chiefly to control the cabbage maggot. The strength required and the method of applying it are given under that insect.

Bordeaux Mixture.—As Bordeaux mixture is used to control flea-beetles and leaf hoppers of potatoes as well as to prevent late blight of potatoes, celery blight and certain other diseases, a formula and method of preparing it are given:

Bluestone (copper sulphate)	4 lbs.
Fresh stone lime four lbs., or hydrated lime	6 lbs.
Water	40 gals.

For convenience this formula is called the 4, 6, 40 formula, it being taken for granted that in most cases hydrated lime will be used instead of stone lime, as it is much more convenient, can more easily be secured and stored and requires no slaking. Hydrated lime, however, if left exposed to the air becomes worthless. Hence it should be kept in tightly fastened paper bags in a dry place.

To prepare Bordeaux Mixture.—Dissolve the bluestone; then nearly fill the tank with water; add the proper amount of dissolved bluestone; start the engine to agitate the liquid; add the hydrated lime or slaked stone lime, and agitate the mixture for about five minutes. If a hand outfit is used agitate by pumping the liquid back upon itself for about five minutes.

Note.—The easiest way to dissolve bluestone in the crystal or lump form is to place 40 pounds of it in a bag and suspend this in a barrel containing 40 gallons of water in such a way that the bottom of the bag sinks only three or four inches below the surface of the water. Leave over night and in the morning all will be dissolved. One gallon of the liquid will now contain one pound bluestone. Small quantities can be dissolved rapidly in boiling water by stirring. Granulated bluestone dissolves very readily and is usually placed in the desired amount upon a burlap screen on the hopper or inlet of the tank and dissolved by the water being poured over it as the tank is filled.

Caution.—Bluestone will corrode iron or tin, so wooden or copper vessels should be used for handling or storing it. Remember too that it is poisonous to livestock, as are most of the insecticides.

Bordeaux Dust.—Bordeaux dust with or without a poison is often used by growers to combat potato blight or other vegetable diseases. Against insects it is not nearly so satisfactory as the liquid Bordeaux. A common formula is:

Very finely powdered dehydrated copper sulphate	12 lbs.
Hydrated lime	80 lbs.
Arsenate of lime	8 lbs.

Often it is advisable to increase the copper sulphate to fifteen or even twenty pounds and the arsenate of lime to ten pounds. In such cases the hydrated lime should be decreased proportionately to make the total of 100 pounds. Of course if there are no insects to combat the poison may be omitted and an equal number of pounds of hydrated lime added in its place to keep the right strength of the copper sulphate.

Unless the grower has a good mixing machine he should buy these dusts ready mixed.

DUSTING AND SPRAYING MACHINES

Only a brief account of these will be given as the grower can secure catalogues from the various companies making them.

Of the larger outfits the writer prefers those that are driven by gasoline engines as more durable and satisfactory. The nozzles on all of these should be so arranged as to spray both sides of the leaves, and the horses should be driven slowly enough to allow the spray to cover each plant thoroughly.

For plots of one to five acres a barrel sprayer should prove satisfactory, the knapsack sprayer in most cases being too slow to be suitable. Where the garden is less than an acre in size a knapsack, or in some cases a compressed air sprayer, will suffice. It is perhaps wise to point out that barrel sprayers do not cost much more than a good knapsack and will last several times as long.

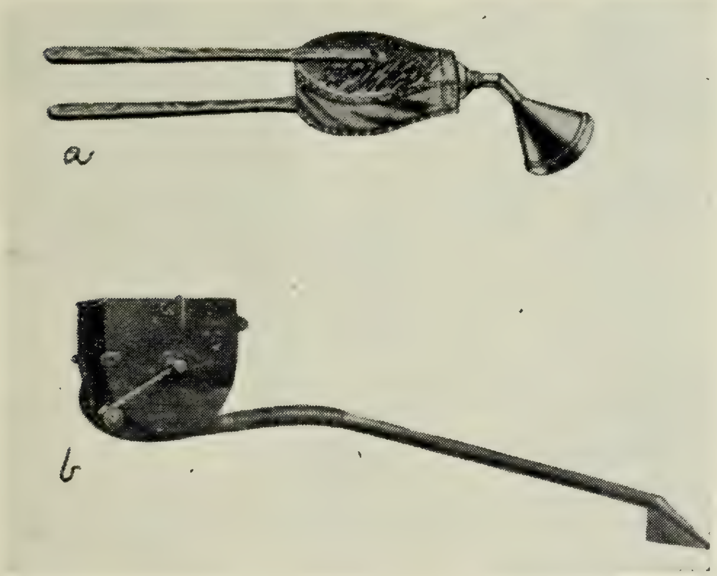

Fig. 2.—(*a*) Small, cheap, hand-bellows duster; (*b*) larger duster of rotary type, carried by straps over the shoulders.

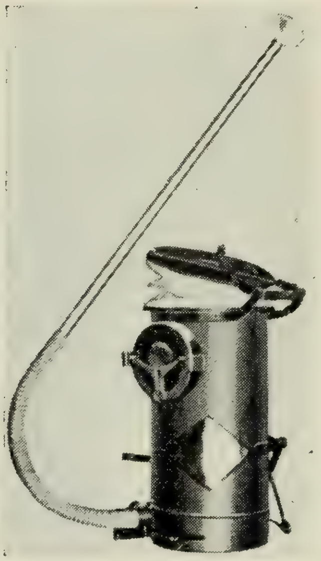

Fig. 3.—Large type of bellows duster, carried by straps over the shoulders.

A good hand duster is a very convenient implement for a vegetable grower or gardener to possess. The best makes cost about $20.00 to $25.00. Three types of hand dusters are illustrated. The first is a very cheap one costing not more than $2.00 but is, of course, adapted only to a very small garden. The other two are each large enough to take care of at least two acres. Power dusters for large acreages are also for sale.

ACKNOWLEGEMENTS

In discussing the different insects the writer has based most of what he has written upon his own experience but for several insects is much indebted to publications by other entomologists in Canada and the United States. Gratitude is due also to Dr. L. O. Howard, Dr. W. E. Britton, Dr. C. J. Drake, and Mr. Arthur Gibson for permission to use illustrations from their publications. In every case the source of the illustration has been stated in the data given beneath it. To Mr. James Marshall thanks are due for his assistance in preparing the illustrations and for helping in the re-reading of the manuscript. The data on the striped cucumber beetle are based upon his study of the insect.

INSECTS WHICH ARE NOT LIMITED TO ANY ONE KIND OF PLANT BUT ATTACK MANY KINDS

Cutworms and Army Worms

Army worms are true cutworms and therefore may properly be considered here as such. The reason they have received the name "army worm" is that they have developed to a greater degree than other cutworms the habit of marching, often in great numbers, from one field crop to another when in need of food.

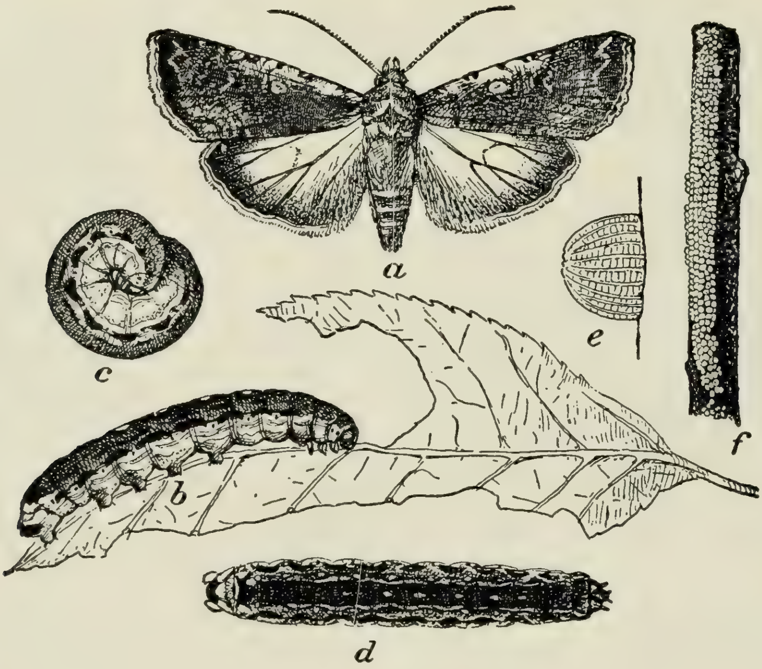

Fig. 4.—Variegated cutworm—(*a*) moth; (*b*, *c*, *d*) cutworms themselves in various postures; (*e*) egg greatly enlarged; (*f*) egg masses on a stem (after Howard, U.S.D.A.).

Cutworms are stout, hairless caterpillars about one-and-a-quarter to almost two inches long when full grown. Figure 4 shows their natural size and also their habit of curling up when at rest. The colour varies with the species, some being nearly white, others dark greasy gray, others brown and others black. Some are a uniform colour all over except that the under side is usually lighter than the upper; others have characteristic bands, stripes or lines along the back or side; and still others have black or other coloured markings on the back. All have three pairs of true legs and nearly always five pairs of false legs.

The adults are stout-bodied, dull-coloured moths with a wing expanse of one-and-a-quarter to one-and-a-half inches. The colour here too varies with the species but almost all are some shade of grey, brown or black, or a combination of these. The moths hide by day and fly at night.

There are many species of cutworms but usually not more than two or three of these are injurious the same year, and some, for instance the army worm (*Cirphis unipuncta*), usually only once in ten or twenty years. Our most common species are probably the red-backed (*Euxoa ochrogaster*), the variegated (*Lycophotia margaritosa*), the spotted (*Agrotis c-nigrum*), the glassy (*Sidemia devastator*), and the greasy (*Agrotis ypsilon*).

Injury.—Although most species have two broods a year, the first in May and June and the second in July and August, the greatest damage, as a rule, takes place in May and early June. The army worm is an exception to this as it does nearly all its damage in July and early August. The variegated and the spotted cutworms are also sometimes quite destructive in these two months.

Cutworms work chiefly at night, hiding by day just under the surface of the soil or under the shelter of leaves or rubbish. Most of them, as the name indicates, cut the plants off at the ground or slightly beneath it. In this way even a comparatively small number can do great damage to cabbage, tobacco, tomatoes, corn or any other crop where the plants are in hills or set far apart. The glassy cutworm and one or two other species, instead of cutting the plants at the ground, feed entirely, or almost entirely, beneath the surface and kill the plants by attacking the roots. Some species have the habit of climbing the stalks of plants, even of fruit trees, and of feeding upon the foliage. These are often called climbing cutworms.

There is scarcely any kind of cultivated crop which is not subject to cutworm attack.

When the worms are abundant and nearly full grown they can destroy whole fields of wheat, oats, corn, tobacco, or other crop in a single night; in fact, there is scarcely any other insect in the Province except grasshoppers which can do so much damage in so short a time.

The injury is almost always more likely to take place when the crop has been planted on a field which was in grass, clover, or weeds the previous fall.

The adults feed upon the nectar of flowers and do no injury to plants.

Life History.—Nearly all our destructive species winter either as partly grown larvae or as eggs in the soil, and in both cases the larvae attack the plants in May and June. Those of most species become full grown before the end of June and then pupate in the soil. By the end of the month or early in July the moths appear and lay their eggs usually on weeds or grass, though some, for example, the red-backed cutworm moth, lay them in the ground. The favourite place for egg-laying is where there is dense foliage such as long grass or weeds. The second brood of larvae becomes full grown usually about the end of July or early in August. The moths from the pupae of these lay eggs during August and September. The larvae from these eggs become partly grown by winter, and remain over winter in the soil. The eggs of the red-backed species, however, do not hatch until the next spring.

Control.—1. It has been stated that the moths prefer to lay in long grass or weedy places or where there is dense vegetation; hence if a crop is to be put on such soil it should be ploughed as early as possible in August and cultivated occasionally to keep down weeds the rest of the season, so that eggs will not be laid there, or if they have been laid before the ploughing, they and any larvae that may have hatched will be destroyed by the cultivation or by starvation.

2. When cutworms have begun to attack plants the best method of control is to use a poison bran bait. There are many formulae for such a bait and the cheapest and apparently as good a one as any is:

Bran	50 lbs.
Paris green 1 lb., or very fine white arsenic	2 lbs.
Water, enough to moisten the whole mixture, about	5 gals.

Mix the bran and one of the poisons thoroughly, then gradually pour the water on the poisoned bran and mix until all is wet and will fall like sawdust through the fingers. The mixing may be done in any large vessel or on a cement floor.

Half a teaspoonful or even less of the above mentioned bait dropped near each plant but not touching it will be sufficient.

If whole fields or large areas are attacked, scatter the bait at the rate of about 15 pounds (dry weight) per acre over the ground soon after sunset. This time of the day is best because the cutworms begin to feed then and like the bait fresh. Usually one application is sufficient, but sometimes a second is necessary.

3. If it is known or suspected that cutworms are in the soil prepare the ground in spring for planting, and a day or two before setting out the plants or sowing the seed scatter the bait broadcast over the ground late in the evening so that the worms will feed upon it and be killed, and the plants thus saved.

Caution.—Remember not to let livestock, including poultry, have access to the bait either when stored or after being scattered in the field; also wash out well all vessels used in making it.

4. If the cutworms are of the underground feeding kind which attack the roots it will be necessary to drill the bait into the ground two or three inches deep. In this case it should be mixed dry and shorts or middlings substituted for bran, as this makes it go through the drill better.

5. Seed-beds may be protected the same way as open spaces by scattering the bait over them thinly.

Wherever there is a great outbreak of cutworms or army worms and they have begun to march forward, the poison bran bait scattered for a few yards all along in front of them will usually destroy them, though occasionally they will pass over it. In that case a furrow, or better two parallel furrows a yard or two apart, should be run ahead of them and the sides pulverized by dragging a log about ten inches in diameter and six feet long up and down the furrow. Cutworms can go up the firm side of a furrow but cannot climb over fine loose earth near the top, as this falls back under their weight. Poison baits should always be scattered along in these furrows. The furrows themselves should be at least six inches deep and should be ploughed carefully.

Usually any outbreak can be controlled completely by the combination of the dust furrow and of the poison bait, but it is seldom that the furrow will be needed.

GRASSHOPPERS

It is only where vegetables are grown in the vicinity of old pastures, waste lands and roadsides that grasshoppers are likely to do any damage to vegetables. This is because it is only in such places that our injurious species breed.

There are many kinds of grasshoppers, some large and some small; but the only ones troublesome in this province are:—the red-legged grasshopper (*Melanoplus femur-rubrum* De Geer), the lesser migratory grasshopper (*Melanoplus atlanis* Riley), and the roadside or clear-winged grasshopper (*Camnula pellucida* Scud.). These are all small, 1 to 1¼ inches long, and all have the same general habits.

Life History.—All three species have a similar life history: The winter is passed in the egg stage. The eggs hatch in May. The nymphs or young grasshoppers feed upon grasses, grains, or other green plants, and change into winged adults in June and July. The adults feed the rest of the season on the same kind of plants as the nymphs but wander more widely. Soon after this stage has been reached, the females begin laying eggs and continue to do so at intervals until killed by the frost in autumn. The eggs are deposited in meadows, pastures, waste lands and roadsides, and are enclosed in little pod-like structures made just below the surface of the ground by the females with their abdomens. These pods are lined and covered by a mucilaginous substance which holds them in place and protects them from the weather.

Control.—1. If the breeding places mentioned above can be ploughed late in fall or early in spring, this will bury the eggs and prevent the young after hatching from reaching the surface.

2. If such lands are put into a short rotation of crops there will be no need to fear damage from grasshoppers any year.

3. Any outbreak can be controlled by the use of the following poison bait—

Bran	12 lbs.
Sawdust	an equal bulk to that of bran.
White arsenic or Paris green	1 lb.
Salt	1 lb.
Water	about 2½ gals.

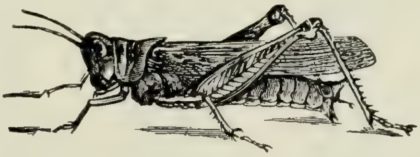

Fig. 5.—Grasshopper.

Mix thoroughly together while dry the bran, sawdust, and poison in a large receptacle or on a clean cement floor. Dissolve the salt in the water and then pour the liquid on the above mixture and stir until every part is wet and will fall freely through the fingers.

If sodium arsenite liquid can be secured, it is a better poison than Paris green or white arsenic as it kills more quickly, and by being poured into the water and stirred, it gives a more uniform poisoning of the whole bait, Moreover, as this is a liquid, there is no danger of the operator being poisoned or injured by arsenic dust when making up the bait. One pint of sodium arsenite liquid is about the equivalent of 1 pound of Paris green or white arsenic.

Apply the bait between 6.00 a.m. and 4.00 p.m. on a bright, warm day, not on a cold, wet or dark day. The above amount is sufficient for at least two acres of infested land. An easy way to apply it is to draw the required amount to the field on a stoneboat or wagon, then using a large pail scatter it by hand like seed grain very thinly over the infested fields or roadsides or wherever the grasshoppers are present. It is possible to sit in a rig and scatter the bait as one drives along. One application is sufficient as a rule, but sometimes a second a few days after the first is desirable. The bait will kill nymphs as well as adults and should be applied as soon as the insects are seen to be numerous enough to justify treatment.

Caution.—Do not allow cattle, poultry or livestock of any kind to have access to the bait. There is usually no danger to cattle or other livestock, except poultry, once it has been scattered over the field, if this has been done thinly.

WHITE GRUB

White grubs are the large, white, curved larvae which live in the soil and destroy the roots of many kinds of plants and bore into tubers of potatoes. The grubs have brown heads and three pairs of legs and their body is always bent into nearly a circle. When full grown they are 1½ inches long and about ⅓-inch thick. They are the larvae of large, stout, brown beetles known as June beetles. These are the beetles we hear and see flying through the air on warm, calm nights late in May and in June. They are often attracted by lights into our homes.

There are about a dozen injurious species of these insects in the Province, all belonging to the genus Phyllophaga, but as they all have similar life histories and habits we shall consider them as one.

Injury.—Both beetles and grubs are injurious. The former feed at night upon the leaves of many kinds of trees, as oak, elm, ash, poplar, willow and cherry, and when very abundant may completely defoliate them. The grubs feed underground on the roots of grasses, cereals, corn, strawberries, young seedling trees including conifers, and many other plants. They also, as said above, bore into the tubers of potatoes and at times into beets and other fleshy roots. It is not uncommon to have whole fields of potatoes or of corn, grass or other plants severely damaged or even ruined by them. Grass in lawns is also often damaged or destroyed. Clover is almost immune.

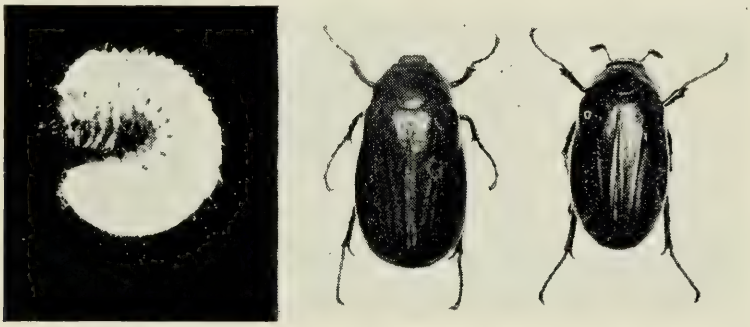

Fig. 6.—White grub and adults—June beetles. (J. Marshall).

Life History.—White grubs have a much longer life history than most insects and this is one reason why it is harder to free the ground from them. The beetles begin to emerge from the soil in May, usually late May, and fly around, especially on warm nights, during the remainder of that month and all through June. Some are found even in July. They feed, as said, on the foliage of trees, some species preferring one kind of tree, others another. During the day the beetles hide in grass or other cover on the ground. In a short time after emerging egg-laying begins. The eggs are white and are placed singly in the soil in small balls of earth at a depth of from 1 to 6 inches and always where the ground is covered with vegetation. The favourite places are old pastures, meadows, and roadsides. Eggs are not laid in bare fields and only seldom in good stands of clover or alfalfa. They hatch in 2 to 3 weeks.

The first year the small grubs feed chiefly upon decaying vegetable matter in the soil and usually do little damage. Early in October they begin to prepare for winter by working down below the plow line. The usual winter depth is between 1 and 3½ feet. Next spring, in May as soon as the ground has thawed out and is in good shape for plowing, they come up again to within about 3 inches of the surface. This year they feed chiefly upon the roots of growing plants or the tubers of potatoes; hence, if abundant, they often do much damage. In early October they again work their way down in the soil, and the following May come up and resume once more their feeding, but only for a short time; for in June they become full grown, then cease to feed and begin to prepare an earthen case in which to pupate.

Pupation takes place in July and August usually within 5 inches of the surface. This stage lasts about 1 month; then the pupa becomes an adult. The new adults do not emerge until the following spring, but remain over winter just where they were inside the pupal cases. An exception has been found to this practice in Manitoba, where at least one species of the new adults leaves the pupal case and goes deep down like the grubs themselves over the winter. As mentioned above all overwintering beetles emerge in spring. Thus the complete life cycle requires in the south-western half of this province three whole years, as follows:—eggs 2 to 3 weeks; larvae 2 full years from June of the 1st year to June of the 3rd year; pupae, 1 month; and adults in the ground and after emerging, 10 months or more.

In some of the colder parts of Ontario and in our western provinces, owing to the shorter summers, four years are required instead of three, and in that case the insect spends three years in the grub stage instead of two.

Control Measures.—Hogs if allowed to run in an infested field will root in the ground and destroy most of the grubs if the soil is not too hard or if it is plowed first. The hogs of course should not be ringed.

Poultry will sometimes follow the plow and devour the grubs as they are turned up.

Numerous beetles can be trapped at night by a lantern placed in a tub of water.

Spraying the trees on which the adults are feeding with arsenate of lead, 2 pounds to 40 gallons of water, will kill large numbers of the beetles.

All the above are helpful but the main method of control is to get rid of the chief breeding places, which are old pastures, timothy or wild grass meadows and waste lands. This is best accomplished by a rotation of crops which will not leave any field seeded down for more than two years, or better still, for more than one year. It must always be remembered that no very susceptible crop such as corn, potatoes, or strawberries should be planted on land broken up from sod, if white grubs are seen to be present, until at least the third year or better the fourth after breaking up the sod. A good practice to follow in such cases is to plow the sod in September to expose the grubs before they go down into the soil and to kill many of the new beetles, then next spring sow oats or barley with clover, using a little more seed per acre than usual. Next year take off a crop of clover and as soon as possible plow the field, work it up and sow wheat that fall. Then by the time the wheat is off the next year, the grubs will usually have disappeared and any crop may be sown. If, however, when preparing the field for wheat many grubs are seen it will be wise to sow clover on the wheat the next spring and by the time the clover is ready to cut or plow, the grubs will have disappeared and any crop may then be planted with safety.

In Manitoba plowing and working the soil in June and July is said to kill the eggs and at the same time fit in well with their method of farming, but such a practice could not well be followed here.

Infested lawns may often be saved by frequent watering through the summer and by using a dressing of nitrate of soda.

In gardens, if only a few plants are being attacked, the grubs may be found by digging and destroyed.

Wireworms

Wireworms, as the name suggests, are hard, slender, round or nearly round worms. There are several species, the colour and size varying with the species. One, known as the wheat wireworm (*Agriotes mancus* Say.), though it attacks other kinds of plants besides wheat, is glossy, pale yellow or straw colour, and when full grown is about 1 inch long. Another common species, the corn wireworm (*Melanotus communis* Gyll.), which also attacks many kinds of plants, is light reddish-brown and about 1¼ inches long. All the other common wireworms in this province resemble closely one or other of the above two.

The adults are called click beetles, because, if placed on their backs, they spring up into the air with a clicking sound. They vary in size, some being about ⅓-inch in length, others nearly 1 inch. The general shape is shown in figure 7.

Millipedes are often mistaken for wireworms, especially in the fall of the year, but may be distinguished easily by the fact that they have numerous legs along the under side of the body, whereas the wireworms have only 3 pairs of legs.

Food Plants.—Wireworms attack a wide range of plants, including almost all cereals and grasses and most vegetables. Clover is usually immune as are also, to a considerable extent, buckwheat and flax.

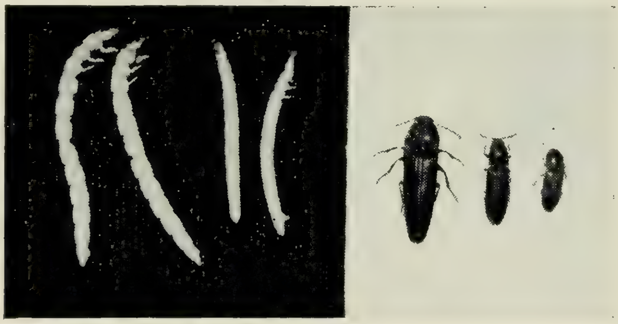

Fig. 7.—Two common species of wireworms and three species of adults, all natural size.

Injury.—The adults feed upon the blossoms of many kinds of plants but rarely do any appreciable damage.

The larvae are among the most destructive of all farm and garden insects. Fortunately they are rarely found to any great extent except in soil that has been ploughed up from old sod. In such soil especially, the second year after the sod has been ploughed, they are often exceedingly numerous and may destroy great numbers of plants either by feeding upon the seed and preventing its germintion or by eating off the roots of the growing plants. Potatoes are commonly ruined by the worms boring into the tubers in all directions and making them unfit for sale. Carrots, parsnips, and beets are also injured in the same way. Injury to roots is usually worst in a cold, backward spring; for in such weather the plants make very little growth and so the roots are eaten off much faster than they can be replaced by the plants.

Life History.—The life history of wireworms is very similar to that of the white grubs. The adults come out of their winter quarters usually in April, and can be found throughout May and most of June. Eggs are laid in the soil, chiefly in grass lands. We have not full data on the eggs but those of several species at least are round, glossy, white and hatch in two to four weeks. The larvae the first year do little harm as they feed chiefly upon decaying vegetation. In October they go below the plow line, though possibly some may remain above it at times. The next spring when the ground is ready to plow and plant, they come up, and this year, because of their larger size, and often too because of the disappearance of decaying vegetation, feed upon the seeds and roots of the living plants and do great damage. In October they again go down into the earth. Next spring they come up and resume feeding for a few weeks. In June they cease feeding and make an earthen case in which to pupate. Pupation occurs in either July or August and lasts about one month. The pupa then changes into the adult which remains in the earthen case, like the June beetle, until the next spring. It may be mentioned here in passing that breaking the pupal case by plowing in July or August will kill the pupae and sometimes the new adults.

The above is the life history of the common so-called wheat wireworm, but the corn wireworm and some other species have a much longer life history, for they remain as larvae not for two years only, but for three and more commonly four. Therefore, after breaking up an old infested sod, it will require longer to free the soil from these than from the wheat wireworm.

Control.—1. The chief method by which farms and gardens are kept free from wireworms is by practising a short rotation of crops. This removes the main breeding places; namely, the old pastures and meadows. When breaking up such a field a good practice to follow is either to plough it early, work it up and sow wheat the same fall or, if this cannot be done, plough it later in the fall, and next spring sow oats or barley. In either case put in clover in the spring. Next year take off the clover, plough early and put in wheat, adding clover again the following spring; or oats or barley with clover may again be used. After this crop of clover has been harvested or ploughed under any crop may follow.

Peas, buckwheat and flax are like clover, very little attacked by wireworms and may therefore also be used in the rotation until the soil is free from the worms.

Corn and potatoes being very susceptible should never be planted in any soil which is known to contain wireworms.

2. It has been observed that wireworms are usually worse in poorly drained soil; hence tile draining will often help greatly.

3. The more rapidly the plants grow, especially in spring, the less likely they are to be killed by wireworms; hence before planting the field prepare the soil well and, if poor, add commercial fertilizer.

4. Baits may sometimes be used on a small scale, especially in gardens, to capture the wireworms. Potatoes with one side sliced off may be placed about 4 inches deep in the soil and 10 feet apart. Stick a short wire painted white into each potato to mark its position. Examine the potatoes once a week and destroy the wireworms present. Replace the potatoes and repeat. This may be done for three weeks in succession and will result in getting rid of many of the wireworms. It should be begun in spring as soon as the ground is warm and the wireworms have come up, as can be determined with a shovel.

Baits of moistened bran and flour kneaded into balls may be substituted for potatoes and in that case they will not be removed, but the worms will merely be picked out of them and a new ball, if necessary, added each time.

5. Seed baits followed by poisoning with calcium cyanide are now being used in some cases by market gardeners where the crop to be planted is a high-priced one:—Plough the infested field in spring as early as the soil is fit. Work up well and as soon as digging shows the wireworms are above the plough line,

sow trap rows 2½ to 3 feet apart of corn, peas, wheat, beans or even potatoes, if the latter happen to be cheap and plentiful. The sowing should be 2 to 3 inches deep. Leave for 2 weeks, then run a plough 4 inches deep along close to the seed row with the landside against it and scatter thinly in the furrow calcium cyanide crystals at the rate of 100 pounds per acre or about ½ pound to 100 feet of furrow. A Planet Junior seed drill may be used for the purpose. Then with the plough at once throw the earth back to cover completely the poison. The calcium cyanide gives off a very poisonous gas which penetrates through the soil and kills the wireworms. This substance costs about 20c per lb. in 100 lb. lots.

Caution.—Calcium cyanide taken internally is a deadly poison. The gas is also poisonous; hence store it in a dry, safe place and label *poison.* When handling stand to the windward side so as not to inhale much of the gas.

6. If wireworms are still present in spite of a short rotation of crops, as is sometimes the case, the cause may be that weeds were allowed to grow in early spring or fresh barnyard manure was applied just before planting and its odour attracted the beetles to lay their eggs. The freer from weeds the garden or field is the better and, if the use of barnyard manure seems to be the trouble, it should be applied in fall and ploughed under before winter, or else commercial fertilizer substituted for it.

Useless or impracticable remedies.—Neither salt nor gas lime will kill wireworms unless applied heavily enough to ruin the crop. Lime has no effect upon them, except that sometimes it may be valuable in promoting better growth. Strychnine, arsenic, corrosive sublimate or any other known poison which might be put on baits will not kill them. Covering the seed with coal tar or gas tar cannot be recommended, as it often prevents germination and usually fails to keep off the worms.

SLUGS

There are several species of slugs. Our most common one is gray in colour, tapers gradually towards both ends, has a soft, slimy body, moves slowly and leaves behind it a trail of slime. When full-grown it is about 1½ inches long and ⅓ to ½ inch in diameter.

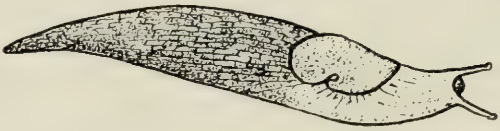

Fig. 8.—Common grey slug (R. Ozburn).

Slugs have sharp biting mouthparts with which they can eat holes out of leaves or by starting at the edge gradually devour the whole leaf itself.

They feed at night or in late evening and early morning. Moisture is a necessity to them; so they shun the daylight and dry air by hiding under leaves or beneath the surface of the ground. They are regularly most abundant and destructive in wet seasons.

Food Plants and Injury.—In a wet spring the foliage of beans and corn is often severely attacked and sometimes much of it eaten. In addition the slugs are fond of feeding upon lettuce, cabbage and cauliflower and eat large areas out of the leaves of these. They feed to some extent on almost any vegetable and in fall are often found boring into tomatoes, beets, carrots and other roots. In dry seasons they usually cause very little damage.

Life History.—The winter is passed chiefly in the egg stage in the ground. The eggs are roundish, bluish white, jelly-like and translucent. They are laid either singly or in small clusters. Another form in which the winter is sometimes passed is as adults hidden in the soil, especially in well protected places such as are afforded by dense vegetation. Cold winters kill a large percentage of both eggs and adults. The eggs hatch in spring, about June. The young slugs become full grown about August, and in September and October eggs are laid. There is only one generation a year.

Control.—1. The old-fashioned remedy of dusting the plants and the ground around them with lime, hydrated lime being the most convenient form, is fairly satisfactory. Salt will also kill the slugs. When a garden or any place has been severely attacked it is a good plan as soon as the crop is off to rake up all refuse and burn it and then dust the soil freely with hydrated lime or a mixture of about equal parts of lime and salt. This will help to lessen the number of the slugs the next year, though it will not destroy most of the eggs.

2. As Bordeaux mixture 4, 6, 40 is a repellent, plants which are being attacked may be protected by spraying both sides of the foliage thoroughly with it.

3. Good results have been obtained in Oregon by a bait of chopped lettuce or clover 16 parts by weight to 1 part of calcium arsenate powder. This bait is scattered in the evening over the ground where the slugs are troublesome.

TARNISHED PLANT BUG

Lygus pratensis Linn.

The tarnished plant bug is a very common brownish insect about ¼ inch long and of the shape shown in the illustration. The nymphs are green or yellowish green and, when very small, look much like aphids but are far more active and when disturbed seek shelter quickly. Both adults and nymphs have very sharp piercing mouthparts with which they penetrate the surface of their food plants and extract the juices. They are said also to inject at the same time a poisonous substance which increases the injury.

Food Plants.—The insect has been described as almost omnivorous. It certainly feeds upon a great number of cultivated plants and also on many weeds and wild flowers. Of the former probably asters, dahlias, chrysanthemums, young peach trees, beets and celery are the favourites.

Injury.—On asters, dahlias and chrysanthemums the injury is caused by the adults puncturing the unopened flower buds and feeding upon them to such an extent that they either fail to open or produce imperfect blossoms. Peach trees, especially in the nurseries, have their terminal buds attacked and destroyed, with the result that a bushy stunted top is formed, which is very difficult to prune in such a way as to develop a good normal tree. Beet leaves when fed upon usually become stunted, crinkled and puckered. Celery is injured chiefly by the adults, and sometimes by the nymphs, too, feeding upon the tender blanching stalks. The affected areas turn brown and wilt. The insect is said also to be the cause of the blackening of the joints of celery, known as black joint, and at times to be a factor in producing rot.

Control.—This is a very difficult insect to combat successfully and no really satisfactory method has been discovered yet, though in the case of greenhouses screening all ventilators and doors is fairly effective.

The number of the insects can be lessened considerably by destroying so far as possible their winter quarters in fall and spring. In the fall, all the remnants of the crop and rubbish of any kind should be cleaned up and burned, and in spring before the buds begin to swell or show green all weedy places and dense grass should be burned over early, so that the adults hiding in them may be destroyed before they become active.

It is claimed by some experimenters that dusting plants with a 3% to 5% nicotine dust, the diluent in which is hydrated lime, or spraying them with ½ pint nicotine sulphate 40% and 2 pounds of soap to 40 gallons of water will protect them. In such cases the younger nymphs will be killed, but the older nymphs and the adults will merely be repelled. Dusting is considered the better of the above two, but it is costly and must be repeated frequently to be effective.

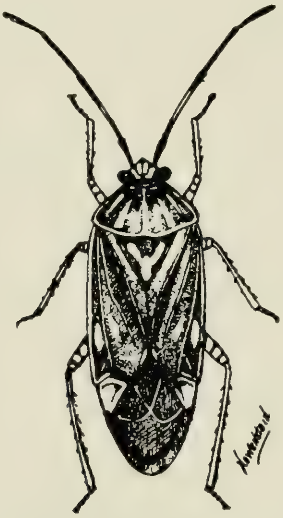

Fig. 9.—Tarnished plant bug adult, enlarged about four times.

Another recommendation sometimes given is that the plants be dusted from time to time with a mixture composed of 20 pounds finely powdered bluestone, 20 pounds dusting sulphur, 30 pounds lime and 30 pounds tobacco dust.

INSECTS ATTACKING ASPARAGUS

Asparagus Beetle

Crioceris asparagi Linn.

The asparagus beetle is a brilliantly coloured insect about ¼ inch long. The general colour is bluish-black. The thorax is red and the wing covers dark-blue marked with lemon-yellow and bordered with red.

The beetle is fairly common almost all over the province, but apparently does not occur in so large numbers as a few years ago, probably because of the attacks of a very efficient parasite.

The larvae are dark brown, grey or olive-grey in colour with black heads and legs. When full-grown, they are about ⅓ inch long.

Injury.—In the spring until the eggs hatch, the beetles do damage by feeding upon the new shoots and eating holes in them. As soon as the eggs have hatched the larvae take a share in the same kind of injury and from then until the end of the season both beetles and larvae may be found together feeding on the plants. If the insects are abundant they cause havoc by eating off all the young and tender parts, leaving only the main branches and the stems. Even the stems are often gnawed by the beetles and the green bark removed. Where the plot is severely attacked in the above manner the result is that the plants are greatly weakened, are unable to store up food in their roots to any great extent and next year produce a very small crop.

Life History.—The winter is passed in the adult stage, the beetles hiding in sheltered places, usually near the asparagus plantation, such as in holes or crevices in logs or stumps, under loose bark on trees or beneath clusters of leaves and rubbish of various kinds. In spring about the time the asparagus plants begin to send up shoots through the soil the beetles commence to leave their winter quarters and proceed to attack the young shoots. Egg-laying begins in a few days and continues for several weeks. The eggs are dark brown, about three times as long as wide and are attached by the one end to the shoots in spring and later on in the season to the leaves and branches. There is usually a row of several eggs together. The incubation period varies from about 5 to 10 days. The larvae grow rapidly and are full size in 7 to 16 days. They then drop to the ground, work their way a short distance below the surface and pupate in a little finely woven cocoon covered with earth. The period spent in the soil before the adults appear varies from 7 to 18 days. Thus the whole time from egg to adult may be passed in less than a month though it averages about a month.

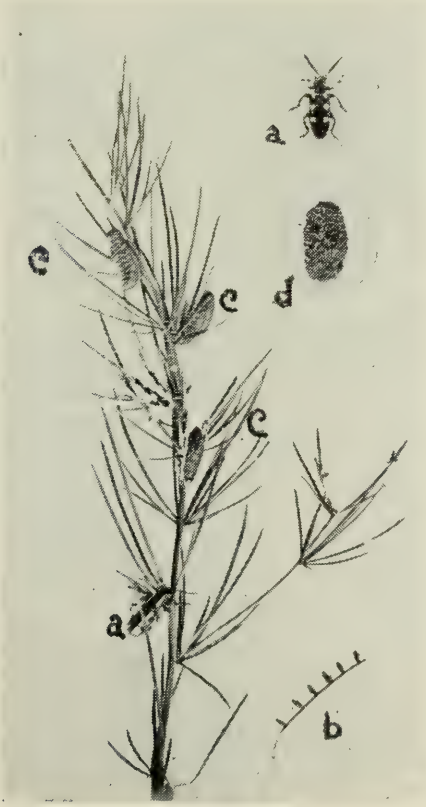

Fig. 10.—Asparagus beetle—(*a, a*) adults; (*b*) eggs; (*c, c, c*) larvae about full grown, all natural size.

Some seasons the new beetles begin to appear by the end of June. There are at least two generations a year throughout the whole province and probably three or at least a large portion of a third in the warmer districts.

Control.—1. The asparagus plots should be well cultivated and well fertilized. This results in the plants growing rapidly, allows cutting to be done frequently enough so that the beetles have little chance to injure the shoots during the marketing season and prevents any eggs that may have been laid from having a chance to hatch.

2. If poultry are allowed to run in the plot they will devour many of the beetles.

3. If the plants are heavily attacked during the cutting season leave a few yards of plants in 3 or 4 rows here and there uncut so that the beetles may cluster on these. Spray such plants from time to time with 2 lbs. arsenate of lead to 40 gallons of water to which has been added ⅓ lb. of calcium caseinate mixed up first into a thin paste with a little water. The calcium caseinate acts as a spreader. Two pounds of soap are often used instead of the caseinate. Dissolve the soap first in boiling water.

4. New plots which are too young to be cut should be protected by spraying with the above mixture whenever they are attacked.

5. After the cutting season is over all the plants should be sprayed with the above poison if there are enough beetles or larvae to justify it. The spraying should be repeated if necessary. It is seldom that more than two applications will be required any year for a commercial plot.

SPOTTED ASPARAGUS BEETLE

Crioceris dodecimpunctata Linn.

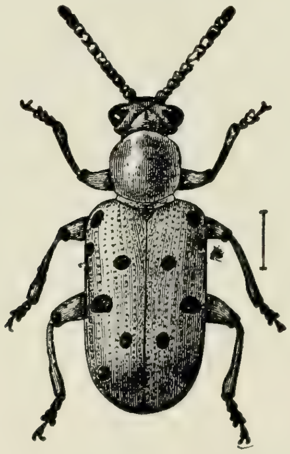

Fig. 11.—Spotted asparagus beetle—adult enlarged; the line to the right shows natural length.

The spotted asparagus beetle is very similar in size and shape to the species just described but can be distinguished easily from it by its red colour and the 12 black spots on its wing covers.

The larvae are about the same size and shape as those of the asparagus beetle, but instead of being grey are yellowish white to brownish yellow or orange. They feed inside the asparagus fruit and so are seldom seen.

Injury.—The beetles injure the plants by feeding upon the shoots during the cutting season and later upon the leaves and branches in the same way as the other species, but as a rule they are not so abundant.

The larvae do practically no harm as they feed inside the berries on the pulp. A single larva may attack several berries.

Life History.—The life history of this species is very similar to that of the asparagus beetle. The main difference is that the eggs are apparently not laid until the berries have at least begun to form. The eggs are elongate, dark green, and are attached by the side to the branches of the plant. The lateness of egg-laying results in the new generation of beetles appearing later than that of the other species. In 1926, in Elgin county, emergence of the beetles from the soil was just commencing on August 11th and large numbers were still in the pupal or larval stage. As 1926 was a cold season, probably emergence would begin under normal conditions about August 1st. There are apparently two generations a year. The winter is spent in the same sort of places as the other species.

Control.—The same control applies to this species as to the asparagus beetle.

INSECTS ATTACKING BEANS

Bean Weevil

Mylabris obtectus Say.

The bean weevil is a small, stout, somewhat wedge-shaped, yellowish-brown or olive beetle about ⅛ inch long and 1/10 inch wide at the broadest part of the body; namely, near the posterior end.

Food Plants.—Our common kidney beans are the favourite but lima beans and cow peas are also subject to attack.

Life History and Injury.—In Ontario the weevil seldom attacks growing bean plants but limits itself either exclusively, or almost exclusively, to stored seed. In this the beetles lay their eggs. The larvae on hatching bore into the beans and feed there until maturity. Each larva makes a separate chamber or cell for itself and a single bean may contain a dozen or more such chambers. In these, when full grown, the larvae pupate and the pupae change to adults. When emerging, the adults remove the surface covering and thus leave the larval chambers exposed to view. Breeding goes on throughout the winter if the storage room is heated, but otherwise stops with the advent of cold weather. In warm buildings the insects may become so numerous as to reduce the beans almost to powder and thus make them a total loss.

Fortunately our winters are cold enough to destroy all stages of the insect, whenever the beans are stored in barns or sheds or unheated buildings. This is no doubt the reason why it is only occasionally that stored beans are attacked in this province compared with what takes place in the warmer parts of the United States.

Control.—1. Infested beans should not be planted, partly because there may be living weevils in them and partly because many of them will not germinate.

2. Beans should be stored in dry unheated buildings where the inside temperature in winter will correspond closely to the outside and so will destroy any weevils present.

3. If at any time beans are being injured they should be fumigated at once with carbon bisulphide—a clear yellowish liquid, costing about 35c. to 50c. per pound.

Fumigation must be done in an air-tight or nearly air-tight receptacle such as a 40 or 50 gallon water or oil barrel. Fill the barrel with seed to within a couple of inches of the top, then pour ¼ pint of carbon bisulphide uniformly over it and at once cover the barrel with two ply of heavy wrapping paper fastened down by a stout cord around the top of the barrel, or use a close fitting lid or a couple of heavy blankets.

If large quantities of seed must be treated a larger receptacle or several barrels may be used and the amount of carbon bisulphide increased proportionately to the size of the receptacle.

Fumigation should last for 48 hours before removing the covering.

The temperature should never be lower than 60° F. and preferably should be 70° or even higher.

If a special chamber is prepared for fumigating large quantities of beans or other seed the amount of carbon bisulphide required will be from 4 to 10 pounds to every 1,000 cubic feet of space, the larger quantity being necessary at 60° F. and the amount decreasing with the increasing of temperature, so that 4 or 5 pounds will be sufficient for 70° or 75° F., provided of course that the chamber is air-tight. If it is not air-tight even larger quantities will be necessary.

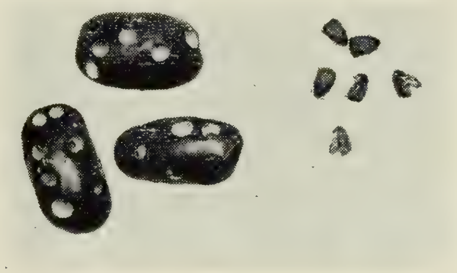

Fig. 12.—Bean weevils and their work, natural size.

The following points should be kept in mind in using carbon bisulphide:—

1. It is useless to fumigate when the temperature is below 60° F. as the insects will not be killed.

2. Good results cannot be expected if the container is not air-tight or almost air-tight.

3. Shorter fumigations than 48 hours are not likely to kill all the insects in all stages.

4. The seed should always be covered as soon as the carbon bisulphide has been poured over it; for, even though the fumes are heavier than air, they will to a large extent escape if there is no cover.

5. Carbon bisulphide does not injure germination nor does it spoil the seed for food.

Caution.—Never bring a lamp or fire, not even a lighted cigar, near the fumes of carbon bisulphide as they are explosive and inflammable. The fumes themselves are not poisonous to man but tend to suffocate if inhaled for a long period.

SEED CORN MAGGOT OR BEAN MAGGOT

Hylemyia cilicrura Rond.

The seed corn maggot, or, as it is usually called in Ontario, the bean maggot, because it has done more damage in this province to beans than to corn, is a little white maggot about 1/4 inch long when mature, which attacks and destroys either the bean seed in the soil in spring or the young bean plants as they are coming through or soon after they have come through the soil.

The adults are greenish-gray, two-winged flies about 1/5 inch in length. They look much like the cabbage maggot flies except for being a little smaller. The illustration on page 28 gives some idea of their appearance.

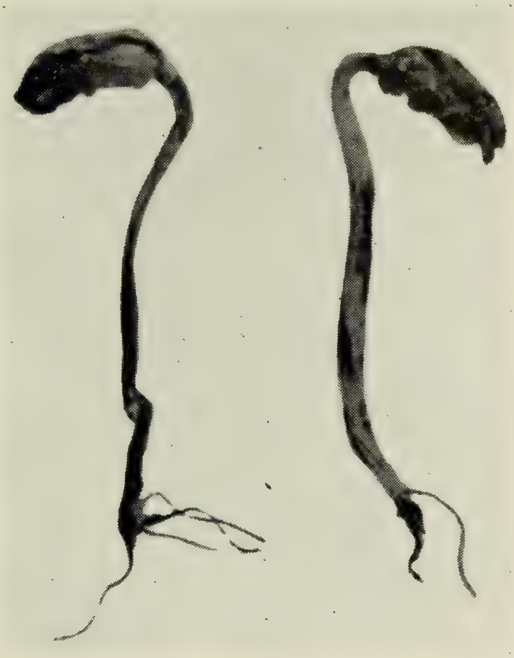

Fig. 13.—Work of seed-corn maggot or bean maggot on young bean plants. (After Gibson & Treherne).

Food Plants.—There is a long list of plants and seeds in which the maggots have been found, but beans, seed corn and seed potatoes are the favourites in this province. It should be kept in mind, however, that almost any kind of decaying vegetable matter is likely to attract the flies to lay eggs on it.

Injury.—It is usually only in a cold, wet spring when germination is slow and growth retarded that this insect causes serious damage. In such seasons the maggots destroy beans either by attacking and killing the seed before it can germinate or by working into the stems soon after germination and killing them. The injury is commonly worst where the beans have been sown in fields which were in clover, alfalfa or grass the previous year, the reason probably being that the decaying roots and stems of such plants attract the flies and cause many eggs to be laid in them even before the beans themselves are planted; then when the beans are planted the maggots from the above eggs attack the bean seeds and plants often apparently in preference to the decaying roots of the previous crop.

Poor drainage is also favourable to maggot injury because the growth and germination in such places are slower.

Seed corn is injured much the same way as beans.

Seed potatoes are occasionally so infested by maggots as to be utterly destroyed.

Life History.—So far as known this insect winters over in the puparial stage, just as the cabbage and onion maggot do, in the soil close to where the maggots have been feeding. The puparia are about the shape of a small grain of wheat and are brown or reddish brown. From them in May, usually several days earlier than the cabbage maggot flies, the adults begin to appear. Eggs are soon laid and are usually placed on or in the soil where there is an odour of decaying vegetable matter or of decaying seeds. Manure recently ploughed under is said to attract the flies. The eggs hatch in two or three days. The maggot stage requires about 11 days and the puparial stage about two weeks. There are apparently three generations or one full generation and two partial ones. Of these the first, which occurs in late May and June, causes nearly all the damage.

Control.—Growers should keep in mind that it is only in a wet spring when growth is backward that the maggot is likely to cause any serious injury. Under these conditions the following recommendations should be of value:

1. Good drainage always helps.
2. There is little or no benefit to be gained by treating seed with kerosene, turpentine, tar or any other substance tested up to the present. None of them will protect it.
3. The more quickly the seed germinates, the less liable the beans are to injury; hence, sow only seed of high germinating power; prepare the soil well to warm it and to be in good shape to bring about rapid germination and growth; and sow the seed shallow, never deep, because the upper soil is warmer than the lower and therefore the seed in it will germinate more quickly.
4. Remember that there is more risk in sowing land broken up from sod, especially clover or alfalfa sod, than other land. In such cases, work the field up well early in spring to make a good seed bed and then if the weather is warm sow early; but, if it is wet and cold, postpone sowing until there have been several days of warm weather to heat the soil.
5. If early sown beans have been ruined by the maggot it is usually safe to work the field up again and re-sow, as by this date the majority of the maggots in the field will have ceased feeding.

INSECTS ATTACKING BEETS AND SPINACH

Spinach Leaf Miner

Pegomyia hyoscyami Ponzer.

The spinach leaf miner is also called the beet leaf miner. It is a creamy white maggot very like the cabbage and onion maggots but, instead of attacking the roots as they do, it makes mines in the leaves. The adults are grey, two-winged flies of much the same shape as the cabbage maggot fly but a little smaller. The grey colour and yellow legs will help to distinguish them from other flies, which might be found around the same plants.

Food Plants.—Spinach, chard, beets of all kinds, including sugar beets and mangolds, are the common cultivated plants fed upon. In addition pigweed and lamb's quarters are quite heavily attacked. A few other weeds are also attacked but to a much less extent. The miner in dock leaves is a different species.

Injury.—The injury is caused by the larvae making mines in the leaves, especially in June. The mined portion of the leaf dies and turns brown or white. As several larvae usually work in each mine and as there may be half a dozen mines in a single leaf when there is a severe outbreak, many plants may be killed. It is not an uncommon sight during such an outbreak to see whole fields of beets or mangolds with fully half of their leaves either dead or severely mined. Yet in spite of this a very large percentage of the plants, as a rule, outgrow the injury and give fair yields, though doubtless not so large as they would have given if there had been no miners. When spinach is severely attacked the crop is usually ruined, because no one wants to buy infested spinach leaves and the time necessary to select only the intact ones is too great to make it profitable to harvest the crop. Fortunately most years the insects are not abundant enough to cause much damage or anxiety. It is only about once in four or five years or even longer that they are very numerous.

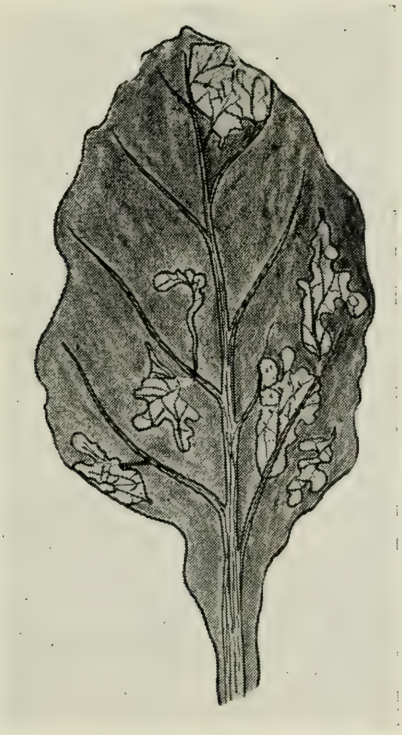

Fig. 14.—Work of spinach leaf miner in beet leaves (J. Marshall).

Life History.—The winter is passed in the soil, just as in the case of the cabbage maggot, in the pupal (puparial) stage. From this in spring the flies commence to emerge towards the end of May and begin laying eggs about the first of June. These are white and are placed on their side in small clusters, averaging about 4 eggs each, on the under side of the leaves. They hatch in four or five days. The young larvae bore directly into the leaves and soon make a conspicuous mine. As there are often many clusters of eggs to a leaf there may be many mines and, as these frequently coalesce, the whole leaf may in this way be killed. When dissatisfied with a mine, the larva commonly leaves it, migrates to another leaf and mines it. Often it leaves this second one and goes to a third or even to a fourth. The larval stage lasts about two weeks, then the larvae leave the mines and pupate in the ground. From the pupae adults begin to emerge in approximately two weeks. There are at least three generations a year, though the last two are only partial generations. The first generation is the one that causes nearly all the damage, natural control factors being sufficiently strong to prevent injury from the second or third generation.

Control.—No really satisfactory control measures have yet been discovered. Spraying with nicotine or other substances fails to do any good, because the spray cannot penetrate through the epidermis of the leaf and reach the larvae within. As the flies are known to be fond of sweet substances and as they apparently do not begin laying eggs for about a week after they emerge it is possible that the beets and mangolds might be protected during the danger period in spring by spraying them with 1½ pounds arsenate of lead to 40 gallons of water to which has been added ½ gallon of cheap molasses. The spraying would only be effective when the weather is dry. It should be applied about 4.00 p.m. on a bright, warm, calm day. The first application should, of course, be made just as soon as the eggs can be found on the under side of the leaves. The eggs are very similar in appearance to the cabbage maggot eggs shown in figure 18, and can be seen easily with the naked eye. A second application made in about four or five days should kill most of the flies which emerged in the meantime and these two should give the plants a chance to make sufficient headway to escape any serious damage.

Caution.—It is not safe to use poison on spinach.

Another method which would help considerably in reducing the number of flies is to destroy all pigweed and lamb's quarters as soon as mines begin to appear in considerable numbers in them. Up to this time they would, of course, serve as traps and entice many flies to oviposit upon them instead of upon the cultivated food plants.

INSECTS ATTACKING CARROTS, CELERY AND PARSNIPS

Carrot Rust Fly

Psila rosae Fabricius

The carrot rust fly larva is the little white or cream-coloured maggot which often ruins carrots and, to a lesser extent, parsnips by burrowing into them, destroying the tissues and leaving rusty stains wherever it works. The larva is about ⅓ of an inch long when full grown, is very slender and has no legs and no visible head, though there is a pair of small black hooks at the smaller end which serve as jaws.

The adults are slender, two-winged, glossy, greenish-black flies about ¼ of an inch long with yellow or yellowish-brown heads and legs.

Food Plants.—Carrots are the favourites but parsnips are also attacked and to a lesser extent celery.

Injury.—All the injury is done by the maggots and takes place at two periods in the season—in spring, chiefly in June, and in fall, chiefly in September and October. The fall injury is nearly always much the more serious. In June the early brood of maggots attacks the young plants, burrows into the tap root, and, if abundant, either kills the plants or checks their growth greatly. The attack is in full headway about the time the carrots are ready to thin. In fall the late brood attacks the carrot and parsnip tap-roots, which are of course well developed by this time. Narrow rusty-coloured furrows are made here and there over the surface, and tunnels through the interior. The tunnelling is usually most common towards the tip of the root, and this portion often becomes dark and rotten.

It is usually in gardens in towns and villages that the plants suffer most, though we have seen a two acre field of beautifully developed carrots so badly infested by October that they were all unsaleable. This field was as well sheltered as gardens usually are; so it may be that the insect cannot thrive in wind-swept or exposed areas. It is possible too that it does not fly far and hence that it is worst in gardens because there is no opportunity for a rotation of crops.

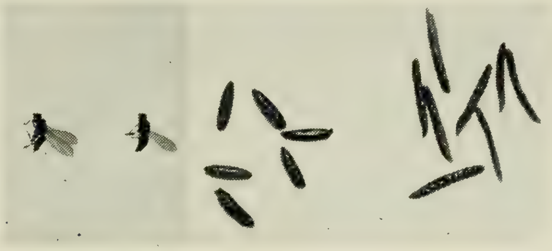

Fig. 15.—Carrot rust fly—adults, larvae and pupae (puparia), all natural size.

The injury to celery is brought about chiefly by the maggots attacking the coarser roots. Usually the plants are vigorous enough to withstand the attack by sending out new roots. Where, however, several main roots are destroyed the plants often become stunted. The grower may not be aware that this is due to the maggots, especially as they seldom bore up into the saleable portions.

Life History.—The winter is passed chiefly in the ground near where the food plants were, in the puparial stage, the puparium being brown, about ¼ inch long and 1/16 of an inch thick, and rounded at each end. Many of the maggots are still immature when the plants are harvested. These continue to feed and grow in storage and finally pupate there. In May the adults begin to emerge and after a few days lay eggs.

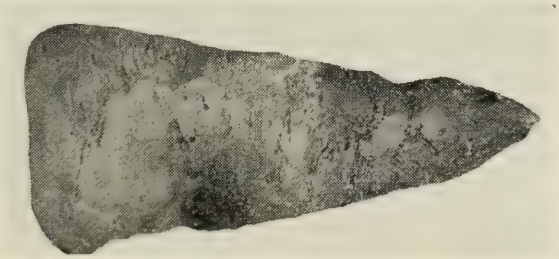

Fig. 16.—Work of carrot rust fly on carrots. Note the scars on the surface. Somewhat reduced in size.

The eggs are very small, white and elongate and are laid chiefly in or upon the soil close to the food plants. They are said to hatch in a week and the maggots seem to require about one month to become full grown. At the end of this period they pupate in the soil and the new brood of flies emerges in August and September and lays eggs for the second brood of maggots. There are apparently only two broods.

Control.—The writer has had no opportunity to work out control measures for this insect and is indebted to the Dominion Entomological Branch for the following suggestions based on a study of the insect in the maritime provinces. The study has not been completed and the Branch points out that the suggestions are only suggestions and not well tested recommendations. It should be remembered by the reader that dates given in these suggestions are about two weeks later than they would be for Ontario.

"Control measures may be classed as follows:

1. Avoidance of the spring generation by late planting;

For those who want table carrots in summer, this is generally effective• The seedlings appear above ground towards the end of the fly season in June, and if any late eggs are deposited about them, the maggots do not find roots large enough to burrow into.

2. Prevention of attack by means of insecticides applied about the seedling plants in spring;

This method is particularly adapted for those who desire early carrots for table use or for sale. The eggs are deposited on the soil about the base of the plants and are very resistant to most common insecticides, as are the larvae which hatch from them. A large number of plots have been treated during the past three years, testing some thirty different materials. The following have been found generally most effective:

(*a*) *Corrosive Sublimate* 1: 1,000 in water at the time when egg-laying is beginning. This acts on the eggs and newly-hatched larvae. If put on a week before or a week after egg-laying, it is not effective. A bad feature in connection with it is that in practically every trial given this material, it has checked plant growth noticeably for a period of from ten days to two weeks;

(*b*) *Powdered Derris Root* at 20 to 25 pounds per acre diluted with fine earth or road dust and applied around the seedling plants before egg-laying begins. Laboratory tests have shown this to have no effect on the eggs and very little on the larvae, so the effect is probably on the adult fly; therefore, it must be on before egg-laying. Over three years this has given consistently good results on all plots. There is no injurious effect to the plant;

(*c*) *Derrisene* at 15 pounds per acre applied in water just before egg-laying begins. This material is effective against the adult and, to some extent, against the larvae, and has given good results over a three-year period;

(*d*) *Crude Naphthalene* at 300 pounds per acre scattered along the row of seedling carrots. In laboratory trials this does not kill any stage of the insect so the action is probably repellent only. In small plots it has given commercial protection at low cost. In contact with seedlings it is injurious, so care must be exercised in its application;

(*e*) *Calcium Silicofluoride.* Laboratory tests of this material against the larvae are promising. No infestation occurred in plots treated in 1926.

3. Avoidance of the fall generation by early harvesting;

Early carrots have commonly reached full size by mid-September, are smooth, crisp and free from maggot. Left in the ground longer, they are liable to maggot infestation. If pulled and stored in sand, they keep as well as those pulled later.

4. Protection by means of insecticides applied about the plant;

Owing to the thick foliage growth, the application of insecticides in the fall has not proved effective in tests."

PARSNIP WEBWORM

Depressaria heracliana DeGeer.

The parsnip webworm is the caterpillar that attacks the blossom heads of parsnips and carrots when allowed to grow for seed. It webs the blossom parts together and by feeding upon them prevents the formation of seed. Like most other insects it is much more abundant some years than others. The caterpillar when full grown is about ¾ inch long, yellowish green in colour with a black head and many conspicuous black spots over its body. The adult is a brown moth of the size and shape shown in the illustration.

Life History.—The winter is passed in the adult stage in sheltered places, often in attics or barns. About June the moths lay their eggs on parsnips and carrots grown for seed and also on wild carrots. The larvae on hatching work their way to the unopened blossom heads, eat into them, web the unexpanded blossom parts together and feed upon them. The result is that the blossoms cannot open properly and of course cannot produce seed. After feeding for nearly a month on the blossoms and neighbouring leaves and becoming nearly full grown the larvae crawl down the plants, eat a hole into the hollow stem, feed there a few days and then spin a cocoon and pupate within the stem. Many persons finding the larvae in such places mistake them for the European corn, borer but the black head and black dots on the body easily distinguish them from the corn insect. In August the pupae change into moths. These fly around for awhile and then go into winter quarters; so there is only one generation a year.

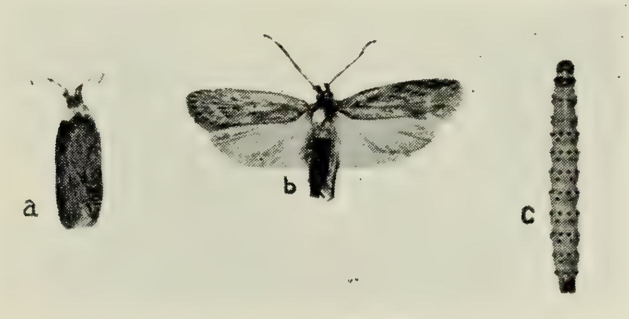

Fig. 17.—Parsnip webworm—(*a*) adult with wings closed, natural position; (*b*) same with wings expanded; (*c*) larva full-grown; all natural size.

Control.—Heavy dusting of infested heads with Paris green 1 part mixed with about 20 parts of land plaster or hydrated lime sometimes destroys a considerable portion of the worms but at other times only a few. The difficulty is to get the poison forced into the webbed portion in such a way that the larvae will eat any of it.

2. Cutting off and destroying all infested heads as soon as seen is the most common method practised. This should be supplemented by the destruction so far as practicable of all wild carrots in the neighbourhood. Even cutting these off as soon as they begin to bloom should help greatly to lessen the number of moths for the next year.

INSECTS ATTACKING CABBAGE, CAULIFLOWER, TURNIPS, RADISHES AND CLOSELY RELATED PLANTS

Cabbage Maggot

Hylemyia brassicae Bouche

The cabbage maggot is probably the most destructive insect which attacks cabbage, cauliflower and radishes. It is a small white maggot about ¼ inch long when full-grown. The body is blunt at one end and tapers gradually towards the other. There are no legs and no visible head, but a pair of black hooks at the smaller end of the body takes the place of jaws and tears apart the plant tissues, thus freeing the juices on which the maggot lives.

The adults are two-winged flies about the size of a housefly. The females are greyish brown or olive brown; the males are darker, being of a steel grey colour.

Injury.—The maggots attack the roots of cabbage, cauliflower, radishes and several other closely related plants. In the case of the former two, the injury is done, not only by the maggots devouring the small roots, but also by their feeding in the main tap-root itself and destroying it. The result is that the plants soon wilt and die. The early crop suffers much more injury than the late. Radishes are even worse attacked than other plants. The maggots work their way into them, make brown tunnels wherever they go and often cause much of the interior to rot. Wormy radishes are of course unfit for table use. Seed beds of cabbage and cauliflower, especially for late planting, are also often damaged severely.

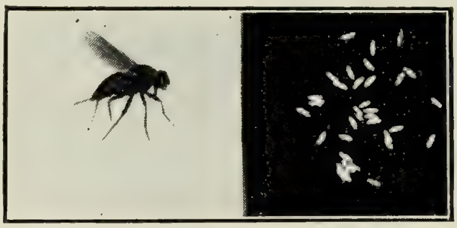

Fig. 18.—Cabbage maggot—female adult and eggs, the latter slightly enlarged.

Life History.—The winter is passed in the pupal (puparial) stage in the ground near the roots of the affected plants. The pupae are reddish brown and resemble in shape and size plump grains of wheat. In spring about the time European plums are coming into full bloom the flies emerge and in 3 or 4 days begin laying their little, white, elongate eggs in the soil close to the stems of the plants. These hatch on an average in 5 days. The maggots feed as described above and become mature in 2 or 3 weeks. They then pupate in the soil and in another period of 2 to 3 weeks, the new brood of flies begins to emerge. There are three generations a year, but only the first generation is a full one, as many of the pupae (puparia) of the other two remain unchanged in the soil until the next spring.

Control.—Much the best method of control is to treat the soil around the base of the plants with corrosive-sublimate solution of the strength of 1 ounce in 8 to 10 gallons of water. Dissolve the corrosive sublimate by mixing it first with a stick in a little water so that it will be thoroughly wet and all lumps broken; then add more water and stir thoroughly until it is all in solution. It requires about half a gallon of water to dissolve an ounce readily. When all is in solution dilute to the proper strength. The liquid should always be applied to the plants shortly before or as soon as the eggs have begun to hatch; for it controls by killing the eggs and the young maggots before the latter have entered the roots. Therefore, if cabbage or cauliflower have been set out very early do not apply it until European plums are in full bloom, as very few eggs will have been laid until this time. If the plants are not set out until that date or later apply the solution the third or fourth day after planting and repeat in a week. Two applications are usually sufficient but many growers prefer to give three, the third being a week after the second. The poison should be poured directly on the soil right against the stem, using about ⅓ to ½ of a cupful to each plant. On small plots this may be done easily by carrying the mixture in a wooden pail and applying it with a cup or dipper. A handy dipper can be made from an empty tomato can by tacking a lath about 14 inches long to the bent-back lid and then squeezing the top to form a spout. On large fields a barrel may be placed on a cart or wagon and filled with the solution, and two lines of soft rubber hose fastened to this. Then two men, one to each hose, can apply the liquid by walking along behind the outfit, pinching the hose between plants to prevent the escape of the liquid and releasing the pressure at each plant. They should, always take care to see that the soil is thoroughly wet for about an inch around each of the plants.

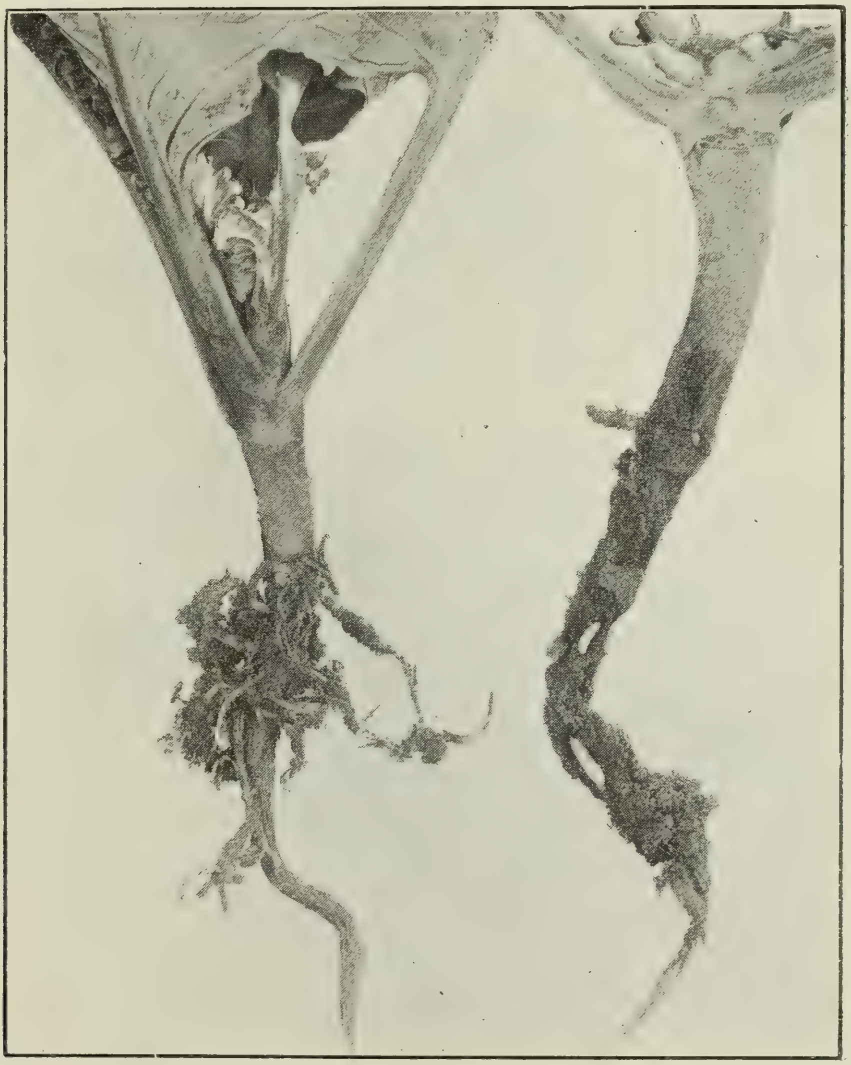

Fig. 19.—Work of cabbage maggot on cabbage roots.

In the case of radishes the corrosive sublimate solution should be applied first on the third or fourth day after the radishes have appeared above the ground unless the weather is cold. In that case it is wise to wait until it becomes warm again, as the flies will not lay eggs in cold weather. Repeat in five or six days. A watering can with the knob or rose removed is a handy way to apply the liquid. Pour it along the rows right upon the plants, and wet the soil for half an inch or more deep. The radishes, of course, should be planted in rows to make treatment easy.

Never treat radishes when they are nearly ready to use. It will do no good and may poison those who eat them; but there is no danger of poisoning if treated at the time mentioned above.

In treating cabbage and cauliflower seed beds saturate the soil thoroughly by means of an ordinary watering can. Wash the can out thoroughly after using to prevent its being corroded, as corrosive sublimate will injure any kind of metal vessel though it does not injure wood.

Caution.—Remember that corrosive sublimate is a deadly poison; hence be sure that none of it is left in any vessel where children or livestock may have access to it. Keep the substance itself labelled *poison*. The antidote is to cause the patient to partake freely of white of egg or milk, and in ten minutes give an emetic.

IMPORTED CABBAGE WORM

Pieris rapae Linn

The imported cabbage worm is a very common insect and is found in every garden or field in which cabbage is grown. When full grown it is about one-and-a-quarter inches long, is about the same shade of green as the leaf, has an indistinct golden line down the back and when examined under a hand lens is seen to be densely covered with very short green hairs dotted with black specks. This hairy covering easily distinguishes it, even when very small, from any other green caterpillar which may be present.

The adults are the white butterflies seen flying about every year. These have a wing expanse of about one-and-three-quarter inches. The wings are all white except a small black area at the tip of the front wings, two small black dots on the front wings of the female, but only one on those of the male, and a single black dot on the hind wing of both sexes.

Food Plants.—The favourites are cabbage and cauliflower. Next to these are turnips, rape, Brussells sprouts, kale and radish. In addition the caterpillars occasionally feed on various weeds and wild plants of the cabbage or mustard family (Cruciferae).

Injury.—Some years the caterpillars are not abundant enough to do much damage but about every second or third year on an average they become so numerous that they strip whole fields of cabbage and cauliflower of almost all their leaves except the midribs and larger veins. They also attack the heads and eat large cavities out of them. At the same time they deposit their dark green excrement in large quantities upon the heads, which, in the case of cauliflower especially, stains the head and makes it look most unsightly. The result is that a large part of the crop of both plants is rendered unmarketable. Usually late or moderately late sown plants suffer worse than the early sown ones, though at times the latter are also much injured.

Life History.—The winter is passed in the chrysalis or pupal stage on the plants in the field or on boards or rails of fences or in any other sheltering quarters. The chrysalids are about three-quarters of an inch long, are roughly triangular in outline and vary in colour from green to grey or brown. From them in spring the butterflies begin to emerge in May and in a short time commence laying eggs. These are yellowish, and are attached singly by the end to the leaves, chiefly on the under side. The eggs hatch on an average in five days. The larvae require two to three weeks to mature. They then change into pupae or chrysalids chiefly on the leaves or stems and in about nine days the butterflies emerge. The life cycle from egg to egg is therefore four to five weeks. There are at least three generations in the province and in the warmer portions probably a partial fourth. Larvae may be found in fields from about the first of June until the severe frosts come.

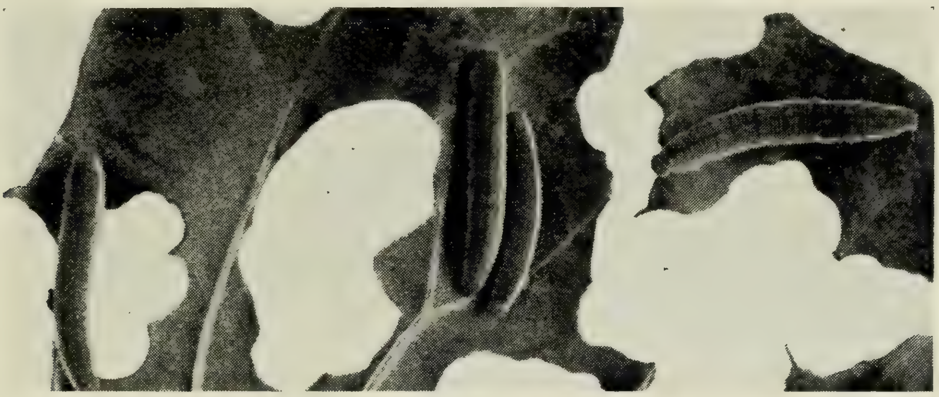

Fig. 20.—Imported cabbage worms, natural size (after Britton).

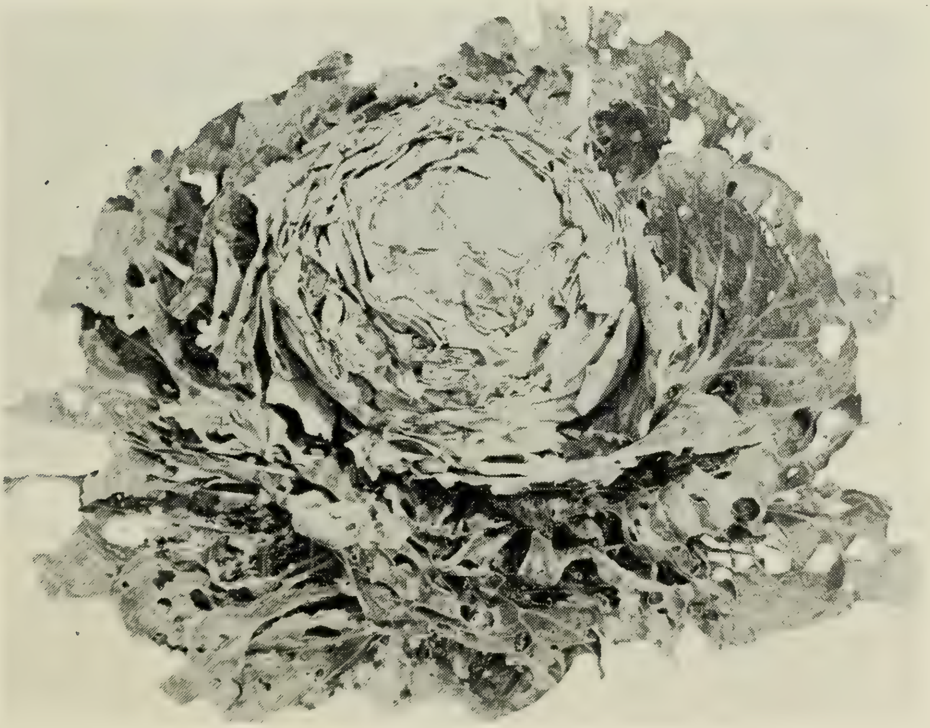

Fig. 21.—Work of imported cabbage worms on cabbage.

Control.—If taken in time the worms are easy to control but if left until they have attacked the heads of the plants control is sometimes rather difficult. The simplest method is to dust the plants as soon as caterpillars are present and in any case just before they begin to head, with one of the following mixtures:

(*a*) Arsenate of lead one part (by measure) to three parts of hydrated lime or gypsum;

(*b*) Arsenate of lime one part (by measure) to four parts of hydrated lime or gypsum;

(*c*) Paris green one part (by measure) to eight or ten parts of hydrated lime or gypsum. The dusting should be thorough, covering every leaf so far as possible, and should be put on at a time when there is no wind and preferably when the plants are moist as with dew in the early morning.

Spraying may be substituted for dusting but is seldom so satisfactory. The same poisons may be used: arsenate of lead at the strength of two pounds to forty gallons of water; or one ounce to one-and-a-quarter gallons of water; or arsenate of lime one-and-a-half pounds to forty gallons of water, or one ounce to one-and-two-thirds gallons of water; or Paris green one pound to forty gallons of water or one ounce to two gallons of water. If two pounds of soap dissolved in water are added to every forty gallons of any the above mixture it will help the mixture to spread and stick better. Three ounces of calcium caseinate mixed up first into a paste with a little water may be substituted for the soap.

Cabbage may be re-dusted or re-sprayed whenever necessary after heads have formed without any danger to the consumer, provided there are no deep cavities present for the poison to lodge in. As cabbage heads grow from the inside, not the outside, the practice of taking off the outer leaves before shipping or using removes all the poison on the surface. It is dangerous, however, to use poison on cauliflower heads after they have begun to form; hence the importance of treating these plants thoroughly just before they are tied up or begin to head.

If cauliflower heads or cabbage heads with deep cavities are being attacked and must be protected the safest method is to mix one ounce of pyrethrum powder in one or one-and-a-half gallons of water and spray this with good pressure directly down into the head where the worms are. It kills by contact and is not poisonous to humans. The pyrethrum should either be fresh or have been kept in an air-tight package.

THE CABBAGE LOOPER

Autographa brassicae Riley

The cabbage looper is a pale green caterpillar about one-and-a-quarter inches long when mature with white longitudinal stripes on the back and sides. The head end of the body is smaller than the rest. When the caterpillar walks it raises its body in a loop after the manner of canker-worms. This characteristic itself will easily distinguish it from the imported cabbage worm.

The adult is a dark-brown moth with a conspicuous small silvery mark near the centre of each front wing. The moth is closely related to and resembles cutworm moths. It has a wing expanse of about one-and-a-quarter inches.

Injury.—The cabbage looper feeds upon cabbage, cauliflower, turnips and other closely related plants, eating holes out of the leaves and boring into the heads. The injury is so similar to that of the imported cabbage worm that it would often be impossible to decide which was responsible, if the presence of the caterpillars themselves did not give the clue. Although present to some extent every year, it is usually not so abundant as the imported cabbage worm and therefore not so destructive. There are, however, years when it is more abundant and more destructive.

Life History.—The full life history has not been worked out for this province but is about as follows: The winter is passed in the pupal stage in a white silken cocoon usually on the plants themselves on which the larvae fed. In spring about the time cabbage plants are getting well established the moths emerge and lay their eggs on the leaves, generally on the under surface. The eggs are circular, whitish, and have ribs radiating out from the centre to the circumference. They hatch in four days. The larvae become full-grown, according to our rearing experiments, in an average of twelve days. The pupal stage requires the same length of time. Four days after emerging the moths begin laying their eggs; hence the life cycle from egg to egg requires approximately one month. There are apparently three generations a year, larvae of the last generation being present up to the end of October.

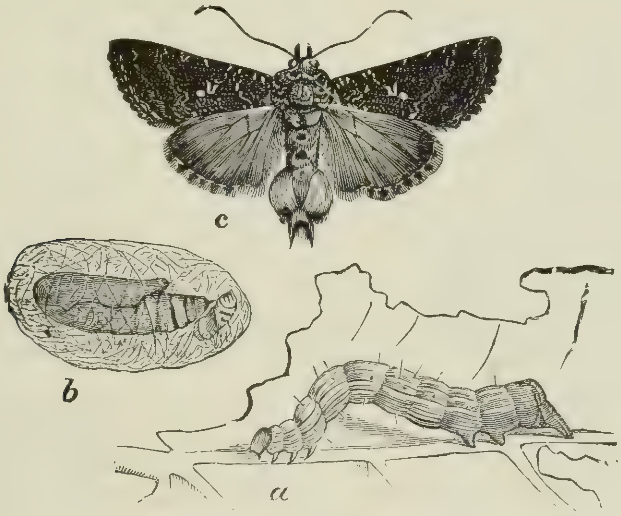

Fig. 22.—Cabbage looper—(*a*) larva; (*b*) cocoon; (*c*) moth; all natural size.

Control.—As the habits of the caterpillar are very like those of the imported cabbage worm the same methods should be used to keep it under control. Control measures should, of course, always be applied before the insect has had a chance to do much damage and should be repeated as often as necessary.

Cabbage Aphid and Turnip Aphid

There are two species of aphids which attack cabbage, turnip and other plants of the same family and which at times cause much damage. These are the so-called "cabbage aphid" (*Brevicoryne brassicae* Linn) and the "turnip aphid" (*Rhopalosiphum pseudobrassicae* Davis). These two can be distinguished readily from each other by the fact that the cabbage aphid is covered with a whitish powder and has a greyish-blue appearance, whereas the turnip aphid is almost naked and is yellowish or light brownish-yellow in colour.

Injury.—Both are of course sucking insects and feed by piercing through the surface of the leaf with their sharp mouth-parts and extracting the juices. They live chiefly on the under surface of the leaves and during severe outbreaks may literally cover that side of the leaves and then swarm over unto the upper surface as well. The result is that in a short time the leaves become so drained of their juice that they turn a sickly yellow colour and the plants either die or are much dwarfed. If the attack occurs late in the season turnips often begin to decay and the odour may be detected half a mile away. Sometimes, however, disease, parasites and other natural enemies step in and save the crop just when it seems doomed. Fortunately most years neither species is abundant enough to do much harm. Of the two, the cabbage aphid is the more common, but outbreaks even of it usually occur only about one year in five. The turnip aphid, so far as the writer knows, has done serious damage in the province only one year, namely 1926, when it occurred in enormous numbers not only over most of Ontario but also over nearly all of Canada. Its attack was limited largely to turnips.

Control.—It is difficult to combat either species successfully without great care and considerable expense. Of several methods tested none was found satisfactory except dusting the plants with a two to two-and-a-half per cent. nicotine dust made by mixing together in a mixing machine five to six pounds of nicotine sulphate with 95 to 94 pounds of hydrated lime. This must be heavily applied to the under surface of the leaves with a hand or a power duster so that every aphid may be hit. To the power duster there should be attached a trailer made of cotton fastened to a light frame to hold the dust down and concentrate it on the plants. At least 50 pounds of dust are required per acre. Dusting should of course be applied promptly once the aphids are seen to be numerous enough to justify it.

As many aphid eggs winter over on the leaves and stalks the feeding or ploughing under of these will help some to lessen the number which will survive but will not completely control the insects for the next season, as winged forms, which are produced from time to time, will fly from one field to another and thus establish new colonies.

DIAMOND-BACK MOTH

Plutella maculipennis Curtis

The diamond-back moth is the adult of a small light-green worm, which attacks cabbage, cauliflower, Brussels sprouts, turnips and many other closely related plants.

The larvae can be distinguished readily from the imported cabbage worm and the cabbage looper by its size: when full grown it is a little less than half-an-inch long; whereas the other two larvae are each an inch or more in length. Its head is greenish-brown with many darker brown spots on it; the heads of the other two species are either pale or dark green with no noticeable markings. Under a hand lens the imported cabbage worm, even in its immature stages, is seen to be densely covered with very fine hairs with little dark specks among them; the diamond-back larva is hairless except for a few short spines. The cabbage looper usually has white stripes down the back and sides, the diamond-back has none.

The adult is a small greyish-brown moth with a slender, dark brown body and a wing expanse of about two-thirds of an inch.

Injury.—Though this insect is not nearly so important as either the imported cabbage worm or the cabbage looper yet it is present to some extent every year and occasionally becomes so abundant as to cause much damage. The larvae feed chiefly on the under side of the leaves and eat small areas almost through them. The epidermis immediately above these areas dies and a hole soon forms. If the larvae are very numerous they do so much feeding that the plants at a distance look almost bleached. In such cases the crop is of course largely ruined. When Brussels sprouts are attacked the insect often bores into the nubs and makes them unsaleable. The worst attacks recorded in Canada have taken place in June, July and August.

Life History.—The life history of this insect has not been carefully worked out in this province. There seems no doubt, however, that the winter is passed in the moth stage under leaves or any other hiding places. The pupae seem unable to stand even a moderate degree of frost and so must all perish with the advent of winter. In the spring, soon after cabbage and other allied plants are set out, the moths appear and lay their tiny yellowish to whitish eggs on the under side of the leaves. These hatch in a few days and larvae may become numerous in June. When full grown the larvae construct a thin lace-like, silken cocoon on the leaves and pupate in this. The whole life cycle from egg to adult may be passed in about 25 days, hence, as all stages are found up to the end of the season, we are safe in inferring that there are at least three generations and possibly four.

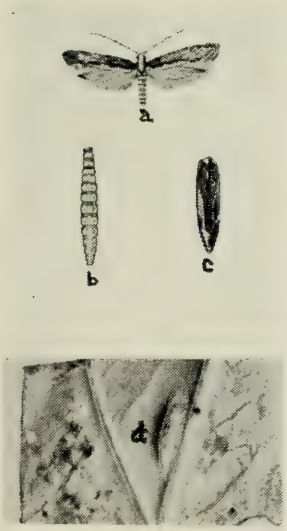

Fig. 23.—Diamond-back moth—(*a*) adult; (*b*) larva; (*c*) pupa; (*d*) cocoon on leaf. (*a, b, c* adapted from Marsh, U.S.D.A.; *d* original). All about natural size.

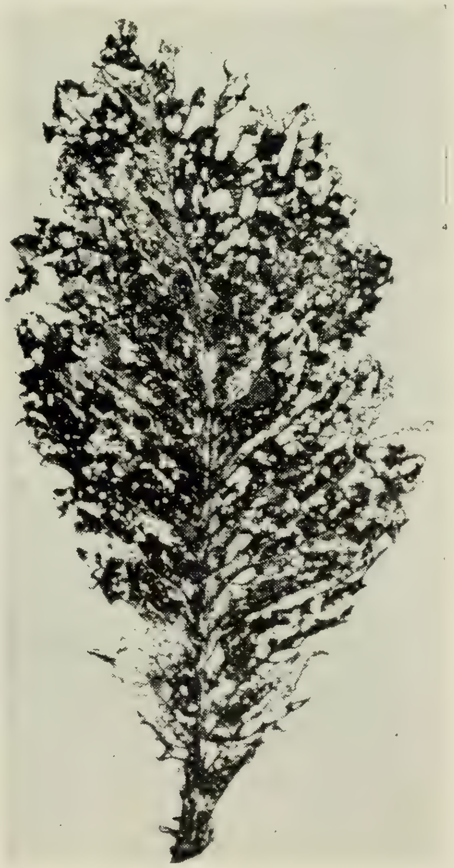

Fig. 24.—Work of diamond-back moth on turnip leaf. (After Marsh, U.S.D.A.).

Control.—The same control measures should be used as given for the imported cabbage worm.

TURNIP FLEA-BEETLE

Phyllotreta vittata Fab.

Many a farmer in this province has from time to time had his turnips destroyed by a little black beetle about one-twelfth of an inch long with a wavy inconspicuous yellow stripe down each wing cover. The injury is nearly always done during the first week or two after the plants have come through the ground. It is brought about by the beetles eating so many holes in the little leaves that these wither up and the plants die. Farmers usually speak of the insect as the "turnip fly." It is, however, not a fly but a beetle and is called by entomologists the turnip flea-beetle or the striped cabbage flea-beetle.

The larva is a yellowish white worm with a brown head. It is rather slender and a little less than half an inch in length when mature.

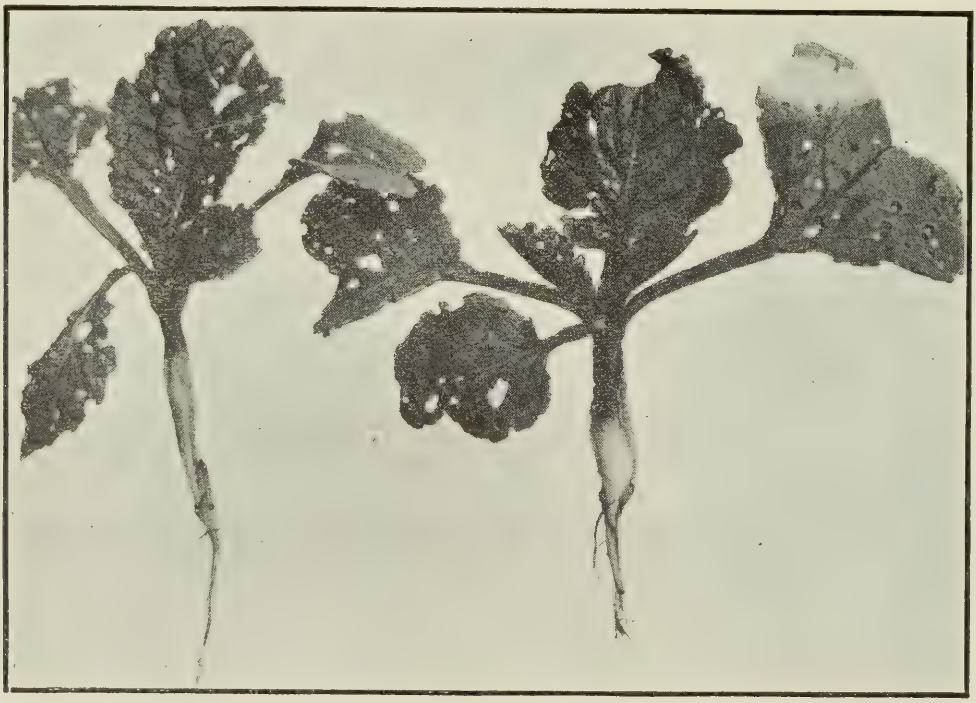

Fig. 25.—Work of turnip flea-beetle on radish leaves, natural size.

Food Plants.—Although the injury to turnips is greatest yet radishes, cabbage and cauliflower are also sometimes severely attacked, the latter two often in seed beds. In addition the insect attacks wild mustard and several other plants of the cabbage family, whether wild or cultivated.

Life History.—The life history does not seem to have been carefully studied. The winter is passed in the beetle stage under leaves or rubbish or anything else that affords good shelter, usually near where the insects have been feeding. In May the beetles come forth from winter quarters and begin feeding on the various food plants. When turnips, radishes or cabbage appear above ground the insects often migrate from nearby places to them and eat holes in the leaves. Eggs are laid around the base of the food plants, sometimes in cavities eaten in the main root. The larvae from these eggs feed upon the roots but they evidently do little harm. Pupation takes place in the ground. There is little doubt that there is only one generation a year. The beetles of the new generation appear in summer and feed upon the leaves of their regular food plants until the appearance of frost, when they go into winter quarters. Almost no damage is done by this feeding as the leaves are then large and can withstand a lot of feeding.

Control.—The destruction of weeds, especially those of the cabbage or mustard family, such as all kinds of mustard, peppergrass and shepherd's purse, will lessen the number of beetles in the vicinity and so lead to less injury of cultivated plants the following year. Feeding off or ploughing under all remnants of cabbage, turnips and closely allied plants in the fall of the year would also help in the same way.

Seed beds of cabbage and cauliflower may be protected by cheesecloth screens, which must of course be put on before the beetles appear in spring and kept on until the plants are about ready to be transplanted.

Turnips sown after the 21st of June are seldom severely attacked, as the beetles will largely have disappeared by the time such plants are through the soil; hence if the early sown turnips are killed it is usually safe to work the soil up again and re-sow at once.

When young plants are being attacked the beetles may be driven off by spraying the plants heavily with Bordeaux mixture 4, 6, 40 formula or with two pounds arsenate of lead to forty gallons of water or by dusting with arsenate of lead one part and hydrated lime ten parts by volume. It has recently been found in British Columbia that a 3% nicotine dust will kill the beetles and thus protect the plants. In spraying the nozzles should be held close to the plants and the same should be done with the outlet of the duster when dusting. This is to save material and to concentrate the substance on the tiny plants themselves. Any treatment should usually be repeated in about four days or as soon as the beetles have again begun to attack.

ZEBRA CATERPILLAR

Mamestra picta Harris

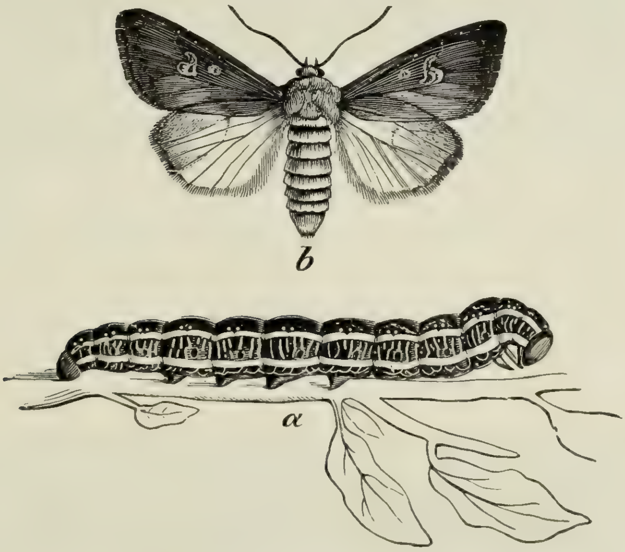

Fig. 26.—Zebra caterpillar and adult.

The zebra caterpillar is a pretty larva with alternate black and yellow longitudinal stripes on its back. It, of course, receives its name from these conspicuous markings. The caterpillar when full grown is nearly two inches long.

The adult is a stout, dark, reddish-brown moth with a wing expanse of one-and-a-quarter inches.

The larvae usually are not abundant enough to do much harm but every once in a while they occur in great numbers in autumn, especially on turnips and cabbage, and almost entirely defoliate these plants. They sometimes are fairly numerous also on celery and a few other vegetables.

Life History.—The winter is passed in the pupal stage in the ground. The moths emerge in May and lay eggs in clusters on the leaves. From these come the first brood of caterpillars. These work during June and early July. When full grown they pupate in the ground, and from the pupae moths begin emerging late in summer and produce the fall brood of larvae which feed in September and early October and are almost always more injurious than the spring brood.

Control.—The caterpillars can be destroyed with considerable ease by dusting the plants heavily with Paris green mixed with about ten times its own bulk of hydrated or air-slaked lime or gypsum. Arsenate of lead or arsenate of lime with about four times their own bulk of lime or gypsum may be substituted for the Paris green. It must always be borne in mind, however, that an arsenical should not be used at this time of the year on any plant which is likely to be fed to cattle or other livestock or which human beings may use.

INSECTS ATTACKING CORN

European Corn Borer

(*Pyrausta nubilalis* Hübn)

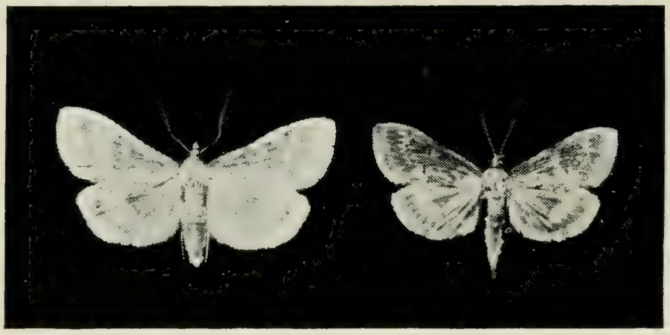

Fig. 27.—European corn borer adults, female on left, male on right, natural size (J. Marshall).

The European corn borer is the most serious insect pest that has at any time been introduced into North America and is likely, unless control measures are carried out thoroughly, to destroy the corn industry in all the main corn-growing areas of Canada and the United States. It is particularly destructive to sweet corn growing, because it readily attacks the ears and renders the crop unmarketable.

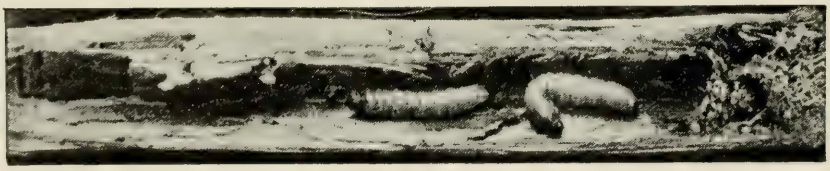

Fig. 28.—European corn borer in burrows in pieces of corn stalks, a little reduced; the larvae should be about one inch long (G. Spencer).

The borer itself is a whitish or brownish white caterpillar sometimes with a pinkish tint and is, when full size, about one inch long. The head is dark-brown and there are many small dots over the body.

The female adult is a creamy-yellow moth with brownish markings on the wings. The male is a little smaller than the female and darker in colour, being pale brown with creamy-yellow markings. (See figure 27.)

Food Plants.—In Ontario nearly all the eggs are laid on corn, no variety being exempt, but a few are also laid on oats and barley with an occasional one on gladioli, dahlias, zinnias and sugar beets. The borers which hatch from the eggs on oats and barley practically all die, because these plants ripen too early for the borers to complete their growth. Hence corn in Ontario is the only plant on which the borer breeds to any appreciable extent. Borers are, however, often found in stout weeds in corn fields; but in such cases they have come out of the corn into the weeds and did not breed on them.

In corn the borers work into and make burrows in any part of the plant large enough to conceal them, from the tassel down to the root. A severely infested corn field is a saddening sight: almost every tassel is broken off; every leaf killed and either fallen off or hanging close to the stalk; the ears are broken down, many of them rotten, the remainder stunted and most of them riddled by borers; the stalks are punctured by borer holes on the outside and darkened with filthy burrows and borer castings inside; thus the whole field is reduced to a tangled mass of worthless, rotting plants.

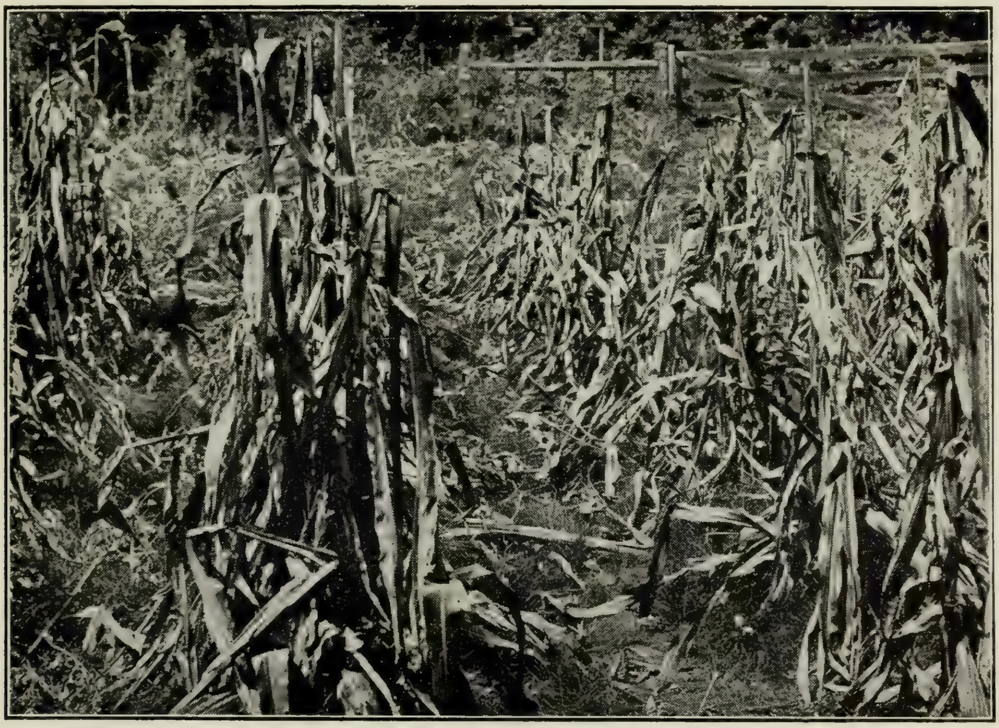

Fig. 29.—Field of corn badly broken down by borers. (Photo by H. G. Crawford, August 19th).

Life History.—The winter is passed as full-grown borers in burrows in any part of the corn plants, including the stubble, large enough to hide them, and also in weeds among or very close to the corn. In spring about June 1st the borers begin to pupate and in about the middle of June the moths begin to emerge and continue to do so for a month or a little more. Egg-laying commences in three or four days after the moths appear. The flat, white eggs are laid in little clusters of from two or three to about seventy on the underside of the leaves. They hatch in about four days. The larvae, soon after hatching, work their way into the plants and make tunnels in the interior, usually working first in the stem of the tassel and causing it to fall over. They become full grown and cease feeding in the latter part of August or early September and remain over winter either in the burrows where they fed or in new ones made for the purpose. In the counties of Essex and Kent pupation of borers and emergence of moths begins about a week earlier than given above.

Control.—Neither spraying nor dusting with poisons has given satisfactory results. The only reliable method is to kill the borers in fall or spring in the corn stalks, stubble or refuse and in the weeds in the corn field. The following is a summary of how this may be done.

1. Wherever possible cut the corn low in the fall of the year to make ploughing under of the stubble easy.
2. If the corn is not cut in fall, break it off in winter by a railroad rail, pole, road scraper, hoe or other device and at once gather and burn it.
3. If the weather is not suitable for breaking it off in winter, cut it with a mower or hoe in spring, or tear it off with a heavy harrow run both ways on the rows, then rake and burn it at once.
4. If the stubble is long cut it with a mower or break it with a roller or planker or disc it twice and roll it before ploughing.
5. Never leave a corn field unploughed, and after ploughing do not drag the stubble or remnants to the surface. Use a disc in cultivating.
6. Gather up and burn before May 20th all corn stalks, cobs or other corn remnants not otherwise destroyed before that date.
7. In gardens pull and burn before May 20th all coarse weeds in the vicinity of corn.

CORN EAR WORM

Chloridea obsoleta Fabr.

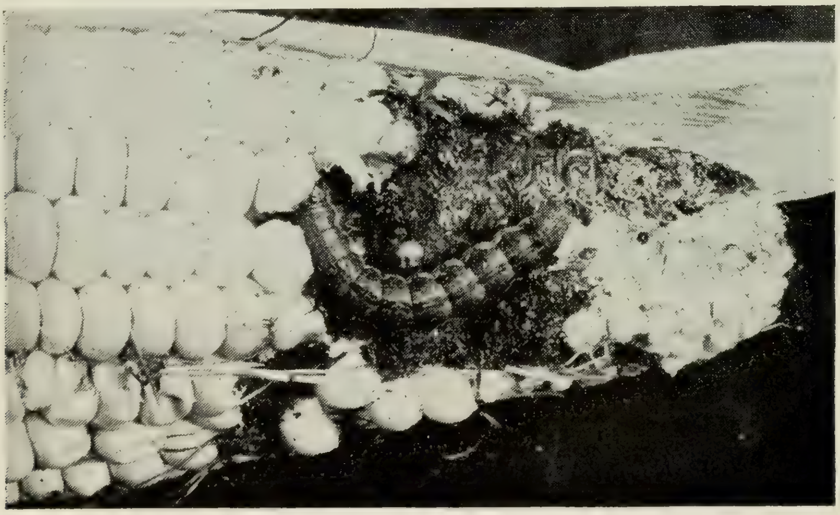

Fig. 30.—Corn-ear worm and its work, natural size.

The corn-ear worm receives its name from its habit of working in the ears of corn. It occurs almost exclusively in late summer and autumn and, while seldom of much importance, occasionally becomes very abundant and then does a great deal of damage to the ears by feeding on the kernels. In 1921, it occurred in such countless numbers all over the province that canning factories in some cases had to cease canning late corn.

Many persons confuse this caterpillar with the European corn borer but they may be distinguished easily by the fact that the European corn borer is only 1 inch in length when full grown and is whitish or brownish white with many small brown dots on its body; whereas the corn-ear worm is 1½ inches long, varies greatly in colour, some being blackish, others brown, others green and others pinkish. Moreover, regardless of the colour, it usually has a broad longitudinal stripe along the side and lacks the small brown spots over the body characteristic of the corn borer. Another difference is that the corn-ear worm limits its work almost entirely to the ear, especially the upper half of it, whereas the European corn borer bores into any part of the plant large enough to conceal it and is even more common in the stalks than in the ears.

The adults of the ear worm are stout moths with a wing expanse of about 1½ inches and the same general appearance as cutworm moths, to which indeed they are closely related. The colour varies greatly, some being dull olive green, others yellowish and others nearly white. The wings are usually bordered with darker bands.

Life History.—This will not be given here in detail further than to say that apparently the insect does not winter in this province, at least to any appreciable extent, and that the caterpillars we find in the corn in autumn all or almost all come from moths which have migrated here from the southern part of the United States, where this insect is a great pest, not only of corn, but also of cotton. In this province almost all of the insects seem to be destroyed by low temperatures while in the pupal or wintering stage.

Control.—There is no satisfactory control method adapted to our conditions and of course control measures are only rarely required in this province.

INSECTS ATTACKING CUCUMBERS, CITRONS, MELONS, PUMPKINS, SQUASH AND VEGETABLE MARROW

Striped Cucumber Beetle

Diabrotica vittata Fab.

By far the most common and destructive insect attacking cucumbers, squash and closely allied plants is the striped cucumber beetle. This beetle is about ¼ inch long with black head, yellow thorax and yellow wing covers with three distinct longitudinal black stripes on them.

The larvae, which are seldom seen, because they live beneath the surface of the soil, are slender, white worms with brown heads. The average length when full grown is about ⅓ inch.

Food Plants.—The favourite food plants of the beetles are cucumber, squash, pumpkin, vegetable marrow, melon, canteloupe, and citron. In the early part of the season they feed to a considerable extent also upon wild cucumbers, beans, burdocks, stinging nettles, pigweed, peas, radishes and curled docks. In addition they may be found on the silk of corn and the flowers of asters, sunflower and several other plants.

The larvae feed on the roots of cucumber and other cucurbits.

Injury.— The main injury takes place from the time cucumbers, melons or other favourite food plants mentioned above have just come through the surface until they begin to send out runners. During this period and especially just after the plants have come through the soil the beetles attack the leaves and often kill the young plants. Sometimes 50% or upwards of the plants in a large area are thus destroyed in less than a week. After the plants are far enough advanced to have begun sending out runners they grow so rapidly that the beetles can no longer do much harm. Moreover, once the flowers appear the insects prefer them to the leaves. Fortunately they do but little harm to the flowers.

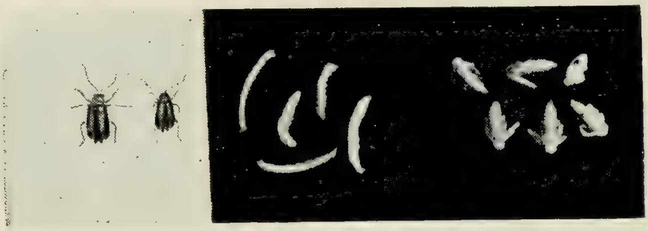

Fig. 31.—Striped cucumber beetle—adults, larvae and pupae, all natural size (J. Marshall).

Another form of injury and a very important one some years is caused by the beetles transmitting a very destructive bacterial disease, known as "cucumber wilt," from diseased to healthy plants. A plant attacked by this disease suddenly wilts and dies. So far as known the striped cucumber beetle and its close relative, the 12-spotted cucumber beetle are the sole agents in the spread of this disease.

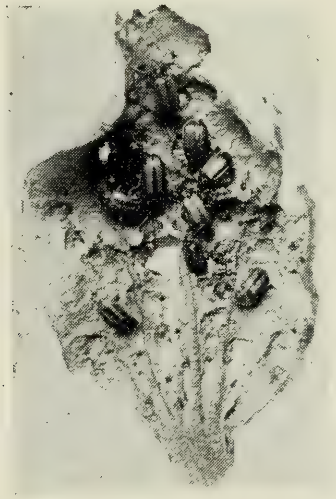

Fig. 32.—Cucumber leaf with beetles feeding upon it, natural size.

The larvae, even though they feed on the small roots and bore into the larger ones, causing deformities in them, seldom do much damage if the plants are thrifty; but if the soil is poor and the plants not thrifty they may cause considerable damage.

Life History.—From our own studies and those of other investigators there seems no doubt that the only stage in which the insect winters is the adult. In this stage they have been found hibernating in dense grass, under leaves in woods and beneath remnants of the crop. In the spring about the time of the full bloom of apples or a little later, the beetles come out and at once attack young cucumbers, squash, melons or similar plants which have been transplanted or have appeared aboveground from the seed. If these are not present, they feed in the meantime on wild cucumbers or on some of the other plants mentioned above but quickly desert them for cucumbers, squash and other cucurbits as soon as they appear. In about two weeks egg-laying begins and continues into August. The eggs are yellow and are laid singly or in clusters in the ground at or near the stem of the favourite food plants. Eggs hatch on an average in about ten days. The larvae feed on the roots as already mentioned. The larval period usually lasts about a month. Pupation then takes place in the soil near where the larvae fed. The pupae are enclosed in little earthen cells and if these are broken the pupae usually perish. The pupal stage requires an average of about two weeks. About the first week in August the new beetles begin to emerge and continue emerging for several weeks. There is only one generation a year. The new generation of beetles feeds chiefly on the flowers of cucurbits and other plants and does but little damage. The beetles go into winter quarters soon after frosts have come in autumn.

Control.—1. It is always helpful if the soil is well prepared and well fertilized, as the plants then grow rapidly and are thus better able to withstand the attacks of the beetles and larvae.

2. It is a good plan in localities where the beetles are abundant to sow the seed thicker than usual. Then, if too many plants are left, they can be thinned out after the height of the attack has passed.

3. Even very severe outbreaks can be combated successfully if the plants are watched and, as soon as the beetles are seen to be present, are dusted heavily with one of the following dusts:

(*a*) Arsenate of lime 1 part, gypsum (land plaster) 20 parts (by weight).

(*b*) Finely powdered sodium fluosilicate 1 part, gypsum 7 to 9 parts (by volume).

(*c*) Derris 1 part, gypsum 20 to 40 parts (by volume).

All three of these dusts gave good results but at present sodium fluosilicate and derris cannot be procured readily; hence until they are more commonly on the market it will be necessary to use the arsenate of lime or gypsum.

Nicotine dusts have been recommended by some but are too expensive and not any better than any of the above.

Hydrated lime will repel the beetles and is sometimes used as a substitute for gypsum in the above dusts, but it tends to stunt the plants and therefore cannot be recommended.

The easiest way to apply the dust is by means of a hand rotary or bellows duster. With one of these machines equipped with a long pipe and an enlarged spoon-like curve at the tip, the dust can be applied to the under side of the leaves, as well as to the upper side and several acres covered in a single day. If there is no dusting machine, a burlap sack does fairly well. A few pounds of the dust should be placed in this; then the operator should walk along the windward side of the row and by giving the bag a shake, dust the plants. The main objection to the bag is that the dust does not cover the under side at all well, though it is there that the beetles do most of their feeding.

To make dusting a success it must be begun promptly after the beetles have commenced to attack the plants and repeated whenever they again become at all numerous. Usually three or four applications a few days apart are sufficient. Dust can be applied much more thoroughly on a calm day than on a windy one, but it is not always possible to wait for suitable weather.

We have not found spraying nearly so satisfactory as dusting.

SQUASH BUG

Anasa tristis DeGeer

The squash bug is a large, stout, dark-brown insect about ⅔ inch long and nearly ¼ inch wide. It attacks all our common cultivated plants of the squash family as squash, pumpkin, cucumber, melon, canteloupe and vegetable marrow. Of these, squash and pumpkin are favourites. Though the insect may be found at times over most of the province, it is somewhat rare except in the southern part along the lake counties from about Toronto west to Windsor.

Injury.—Both adults and nymphs feed on the leaves of squash and the other plants mentioned by piercing through the surface with their sharp mouthparts and sucking up the juice. In the course of this operation it is believed they inject a poison into the tissues which increases the injury. The first evidence of attack is usually the formation of pale green areas here and there on the leaves. These areas later turn brown, die and wither. If the insects are very abundant many vines may have all their foliage turn brown and die, much as if a fire had run over them; but it is seldom that the injury is nearly so severe as this, the bugs usually being only numerous enough to destroy a few plants or a number of leaves here and there throughout the plot. Probably their habit of feeding together in groups while they are young helps to prevent more general injury. Occasionally some damage is done to the fruits by the insects feeding on these and making small cavities on the surface but usually these are insignificant; for fruits are seldom attacked until after frosts have killed the vines. The insect, however, is capable of doing great damage and the fact that it seldom does much seems to be due to its being well kept under control by natural factors and by the practice of cleaning up fields in the fall of the year. Usually gardens in towns and villages suffer more than open fields, probably because the surroundings in such cases afford more favourable hiding places for winter-quarters for the bugs than they could secure in the open.

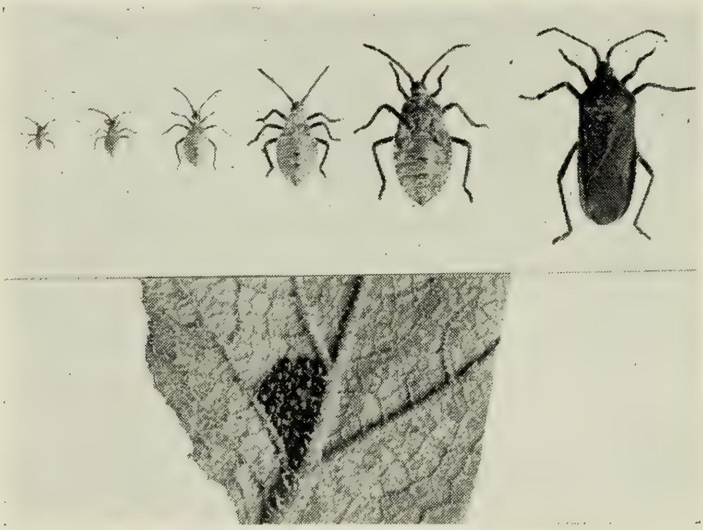

Fig. 33.—Squash bug, showing different stages of nymphs, an adult and egg mass on leaf, all natural size (J. Marshall).

Life History.—The winter is passed in the adult stage in any good shelter, such as afforded by barns, sheds, heaps of stones, piles of boards or of firewood, brush or even garden refuse. The adults usually do not emerge from these winter quarters until June, though we have occasionally seen them on plants in the latter part of May. Egg-laying begins in June, is most common the latter half of July and ends about the first week in August. Eggs are laid in more or less loose clusters of from 4 to 50 eggs each. They are placed on the under side of the leaves but a few may be found also on the upper surface. The clusters can easily be found, as the eggs are large and conspicuous. When laid they are yellowish cream but soon turn light brown and before hatching a dark chestnut brown. They hatch in 7 to 17 days. The nymphs for a few hours after hatching are green with red heads, antennae and legs. The red soon turns black and the green of the body becomes in all the later nymphal stages gray or grayish brown. For some time after hatching all the nymphs from a single egg cluster feed together, usually on the under side of the leaves. As they grow large they separate. The nymphs mature slowly, usually requiring a month or more to reach the adult stage. Often the later ones are still in the nymphal stage when frost kills the vines. In such cases both nymphs and adults may be found feeding together on the fruits. All nymphs either become adults or perish before winter.

Control.—1. Cleaning up the plot and burning all remnants of the crop before winter helps to destroy many adults that would otherwise winter over. So likewise does the removal of all rubbish, brush, lumber piles, etc., in the vicinity which would afford convenient winter-quarters for the insects.

2. If there are only a few plants to protect, this can usually be done most cheaply by collecting the adults from time to time in June and early July and throwing them into a vessel containing a little kerosene alone or kerosene and water. A search should also be made at the same time for egg masses and these either crushed or removed. The collecting of the bugs can be made easier by placing a few pieces of boards or shingles here and there among the plants. The insects will hide under these at night and can thus be collected readily in the mornings.

3. If large areas require control measures the best method we have found is to use nicotine dust, a dust containing 2% of nicotine guaranteed to be 100% free, the remainder being hydrated lime. This has killed with us practically every nymph and adult which was hit. If this dust cannot be secured conveniently the next best is an ordinary nicotine dust made by mixing together 6 to 7½ pounds of nicotine sulphate 40% and 94 to 92½ pounds of hydrated lime. This gives a dust containing about 2½ to 3% of nicotine. These dusts are expensive but usually 50 pounds will treat a large area, because only those plants need be treated on which the bugs are seen to be present. In dusting it is necessary to treat the under surface as well as the upper so as to hit all the bugs present, and if the 2½ to 3% nicotine dust, mentioned above, is used instead of 100% free nicotine dust it will be necessary to treat also the ground beneath the plants heavily; because if this is not done many of the bugs will be merely stupified and after falling to the ground will recover; whereas if there is dust there it will insure the destruction of a much larger percentage of them.

About the middle of a hot calm day is usually the best time to apply the dust.

MELON APHID

Aphis gossypii Glover

The melon aphid is so rarely troublesome in Ontario that only a brief account of it is given here.

The aphid varies in colour from nearly white to dark green. Its favourite food plants are melons and cucumbers but it also feeds to some extent on many other plants including weeds. It is fairly common in greenhouses. In addition it is one of the chief agents in disseminating the disease known as cucumber mosaic.

In the field melons are not usually attacked by the aphids until the vines have just begun to run. When, as occasionally happens in the south-western part of the province, these aphids become abundant, the leaves are curled, the plants become sickly, dwarfed, and some of them die, and the whole crop is greatly lessened.

The aphids winter over in the egg stage on a garden plant which often runs wild known as live-for-ever or common orpine (Sedum purpureum). They also winter in greenhouses where breeding continues all through the winter.

Control.—The same method of control should be used as for other aphids attacking vegetables; namely, dusting the plants with a 2% nicotine dust. This must be applied thoroughly to the under side of the leaves on a warm, calm day. Dusting should be done promptly once the aphids are seen to be likely to injure the plants. In greenhouses the usual fumigation with tobacco or with hydrocyanic acid gas will control the insect.

INSECTS ATTACKING ONIONS

Onion Maggot

Hylemyia antiqua Meigen

The onion maggot is a small white maggot resembling closely the cabbage maggot and having similar feeding habits except that, instead of attacking cabbage and closely allied plants, it attacks onions and to a slight extent leeks and garlic.

The female adult is an ash-grey or olive-grey two-winged fly just like the female cabbage fly. (See fig. 18). The males are darker and a little smaller, and are almost identical in appearance with the cabbage fly males.

Injury.—The maggots bore into the leaves, stem and bulbs of the young onions and by tearing the tissues and sucking the juices kill them. Later in the season they often cause considerable loss by working in the bulbs and causing them to rot or become unfit for sale. The amount of damage varies greatly with the year. Some years are unfavourable to the insects and in these there is very little damage done; others are favourable and in them the damage in some fields may reach as high as 75% of the crop.

Life History.—The winter is passed as pupae (puparia) in the soil near the plants fed upon. A pupa looks very like a large, plump grain of wheat but is brown or reddish-brown in colour. In May the flies begin to emerge and continue doing so for several weeks. After a week or a little longer the females begin to lay eggs. These are white and of the same shape and size as those of the cabbage maggot. (See fig. 18). They are usually placed in the soil close to or against the onion plants though later in the season some are laid also on the bulbs. Eggs hatch in about six days. The maggots feed as described above and become full-grown in two to three weeks and then pupate in the soil. The pupal stage is about the same length as the larval, thus the life cycle from egg to egg requires about seven weeks. There are three generations a year, but the second and third are only partial generations. Larvae are found in the field right up to the end of the season.

Control.—The best method of control is to spray the plants with a lubricating oil emulsion. There are several ways of preparing the emulsion, but the simplest for most growers is by using the following formula:

Lubricating oil	1 gal.
Bluestone (copper sulphate)	2 oz.
Hydrated lime	2 oz.
Water	1 gal.

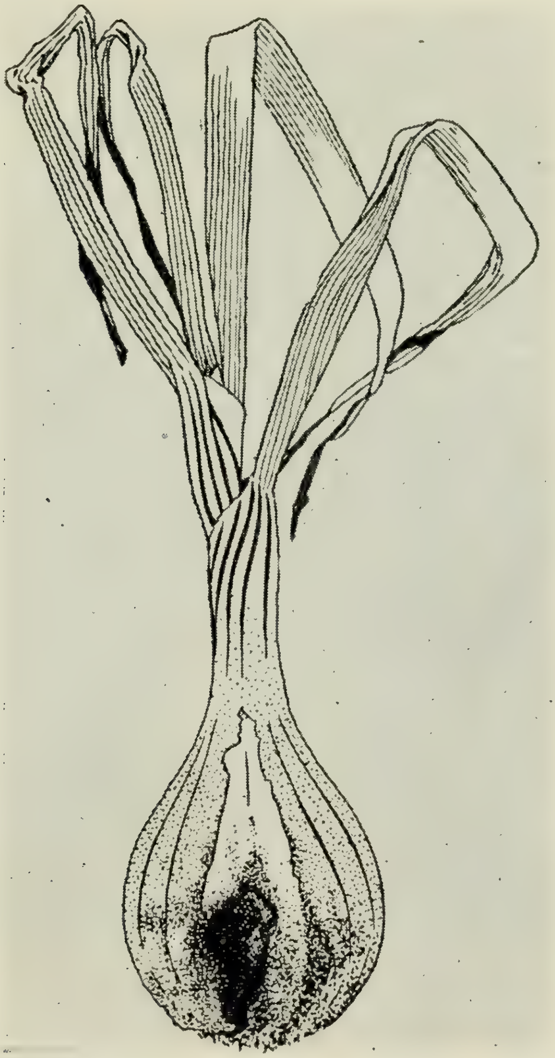

Fig. 34.—Work of onion maggot. (After Gibson and Treherne.)

Dissolve the bluestone (for methods of dissolving see page 4) and dilute with the water to one-half gallon. Mix the hydrated lime in the other half gallon with water, then pour the latter into the former or vice versa and stir at once. This makes a gallon of Bordeaux mixture. Pour this gallon into a gallon of oil, stir for a couple of minutes and then pump the mixture through the spray pump with good pressure either from one vessel into another three times or back upon itself into the spray tank until it seems to be thoroughly emulsified. Then dilute with water to 40 gallons. This gives a spray containing 2½% of lubricating oil. So long as the above proportions are kept any quantity desired of the mixture may be made up in the same way.

The lubricating oil must possess the following characteristics:—a specific gravity of .87 to .93 at 20 degrees centigrade, a viscosity of 90 to 200 seconds at 100 degrees F. and a volatility of not over 2%. Only oils with these specifications are satisfactory. They can be secured from almost any of the large oil companies and cost at time of writing thirty to thirty-five cents a gallon in barrel lots.

Four applications should be made at intervals of a week and at each application the mixture should be sprayed with good pressure right down upon the plants, the nozzles being held close to them, so that every side of the plant and also the soil immediately around it will be wet, otherwise control will not be secured.

The best time for the first application in this province has not yet been definitely worked out, but our tests in 1925 and 1926 indicate that it should be about the time apple trees are coming into bloom, as that is as early as any of the eggs are likely to be laid.

Another method which some years has given good results, is to plant multipliers or cull onions, not shallow, but 2 or 2½ inches deep in the rows when sowing the seed. These will grow much faster than the seedlings and will attract the flies to lay many eggs upon them, thus saving the seedlings. In June, when examination reveals that the maggots in them are nearly full-grown—about ¼ inch long—these trap onions should be dug up and carried away and the maggots destroyed. For convenience it is well to place the multipliers or culls in only about one row out of twenty and in each of the selected rows to put about twenty in a space of a yard or a little longer, at intervals of 50 to 100 feet.

In a dry season the value of the trap onions can be still further increased by putting a poison bait alongside each group of them to entice the flies to drink it and thus perish. The formula for the bait is—

Sodium arsenite	¼ oz.
Molasses	1 qt.
Water	1 gal.

Dissolve the arsenite in a little of the water by boiling. Pour the molasses into the remainder and stir well. Then mix the two solutions together. The mixture should then be poured into fairly deep tin cans such as canned salmon cans about 1½ or 2 inches deep by 3 inches wide until the can is at least half full. A little excelsior should be placed in each can for the flies to rest upon when feeding. The cans must be replenished from time to time, and after heavy rains should be emptied and refilled. The bait should be kept going until the end of June or at least until the trap onions have been removed. Success with baits depends largely upon the dryness of the weather and the inability of the flies to secure moisture nearby.

ONION THRIPS

Thrips tabaci Lindeman

After the onion maggot, the onion thrip is the most destructive insect enemy of onions, and in dry, hot seasons often causes very great loss. In a cool, wet season it is usually not abundant enough to do much damage, partly because such weather is in itself unfavourable to it and partly because drenching rains wash off and kill a large percentage of the tiny creatures.

The light-yellow to brown adult is very small, being only about 1/25-inch long. It has two pairs of very frail, feather-like wings fringed with hairs. (See fig. 35). With such wings the insect is not a good flier against the wind, but can fly fairly long distances with it.

The nymphs have the same general shape of body as the adults but are, of course, smaller and have no wings. They are either white or pale yellow.

Food Plants.—Onions are the favourite food plant; but cabbage, cauliflower, cucumber, tomato and, in fact, most truck crops are fed upon freely and often serve as secondary breeding plants. Weeds and grasses are also infested to some extent. Moreover, the thrip is common in greenhouses.

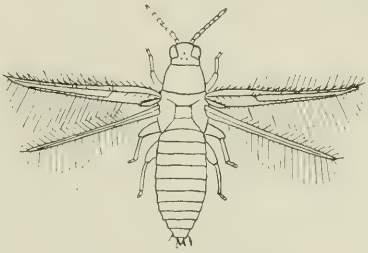

Fig. 35.—Adult onion thrip, greatly enlarged. (R. Ozburn)

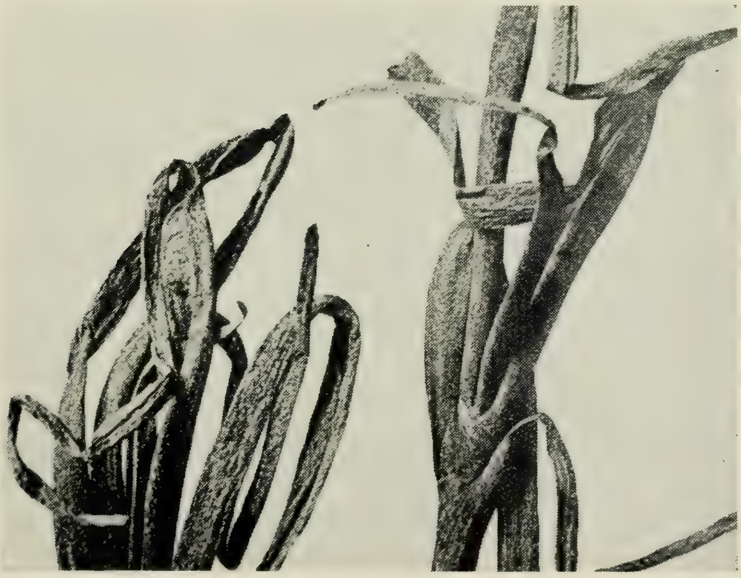

Fig. 36.—Work of onion thrips. (After Horsfall and Fenton).

Injury.—Both adults and nymphs attack the onions throughout the season and feed by rasping or tearing the tissues and then sucking the juices. Wherever they work a small white or silvery blotch appears. When the thrips are very numerous the whole field soon begins to show a whitish, bleached appearance and the leaves wilt and fall down as if struck by some sudden blight. The result is that the crop is either almost ruined or very much reduced in quantity, especially if the attack takes place early or moderately early in the season, when the plants are still far from mature.

Life History.—The winter is passed in the adult stage under piles of onion refuse, such as tops, screenings and culls, or among any green onions that have been left growing in the field. The thrips also winter in dense or weedy places and in fields of alfalfa. Many of them, too, are in greenhouses where they continue to breed all winter. In spring, soon after growth has begun, the adults in the outside hiding places become active and gradually find their way to onion fields or often first to early cabbage and other plants and later from these to onions. Greenhouses are also a source of infestation in spring. Eggs are laid in the leaves of onions or other host plants. The eggs are very small—too small to be seen by the naked eye—and are inserted by a saw-like ovipositor into the tissues of the plants. They hatch in about four days. In six or seven days more the nymphs become full grown and then enter the soil about two inches to pupate. The pupal stage requires an average of about four days. Hence the life cycle from egg to adult may be passed in two weeks. As the insects are present and breeding from May until October there are many generations in a season; thus, even though there may be only a few adults in May, the rate of reproduction is so rapid there may be countless numbers in July, August or September, if weather conditions are favourable.

Control.—The most important thing in control is prevention: Leave no suitable places for the thrips to winter over in, or destroy them in these places in spring before they become active. Hence in fall a complete clean-up should be made of the onion field, so that there will be no green onions left and no piles of tops or of culls or screenings. All these should be burned or ploughed under thoroughly. In spring all headlands and all weedy and grassy places should be burned over carefully before the thrips become active. At the same time the thrips in greenhouses in the neighbourhood should also be destroyed by fumigating the houses several times at intervals of a week or ten days with tobacco or hydrocyanic acid gas.

In addition it is wise, wherever it can be managed, not to grow onions near alfalfa fields or any kind of field likely to provide good cover for the thrips in winter. In the onion field itself the crop is likely to be worse infested if a practice is made of growing sets, as these come on earlier than the seed onion, and so the thrips get a start on them and then gradually spread over to the seed onions, often causing a much worse infestation than if there had been no sets. If, however, sets are grown it is wise to spray them very thoroughly as soon as the thrips are seen to be present with nicotine sulphate 40% and soap at the strength of ½ pint of nicotine sulphate 40% to 40 gallons of water to which has been added four pounds of soap dissolved in boiling water. Common laundry soap may be used. The spraying should be repeated in seven to ten days to destroy the nymphs which will have hatched in the meantime from the eggs—for the eggs are not affected by the spray—and also to destroy adults which will have come from the pupae in the soil.

It is often recommended that the whole onion crop should be sprayed with the above mixture from time to time throughout the season. When the plants are young, spraying, if repeated in a week or 10 days, is quite effective and will do a great deal to prevent loss at that time of the year; but once the plants become large, it is not very satisfactory, because the dense foliage then makes it almost impossible to do sufficiently thorough work to prevent large numbers of the thrips being left alive.

In spraying it is very important to use high pressure and to cover every side of the plant with special care and especially to see that the liquid is driven forcibly right down into the centre where many of the thrips are hidden in the axils of the leaves. In large plantations, to avoid injuring the plants by hauling a spray machine up and down many times, large arms or booms may be attached to the frame of the outfit and to these long lines of hose fastened. Then by swinging the arms out gradually quite a wide area can be done each round and thus only a few rounds be necessary to complete the field.

Dusting with nicotine dust will kill a good many of the thrips but has not proven nearly so satisfactory as spraying.

It is important not to forget that the richer the soil the better the plants withstand attack by thrips, hence it is a good plan to use commercial fertilizer on a poor soil and to prepare the seed bed as well as possible.

INSECTS ATTACKING PEAS

Pea Weevil

Mylabris pisorum Linn

The pea weevil is much the worst of all pea insects and has been responsible for great losses and for many farmers abandoning pea-growing.

The adults are stout, oval, brownish beetles, about ⅕ inch long, with white and black mottling on the back.

Food Plants.—Peas are the only plants fed upon.

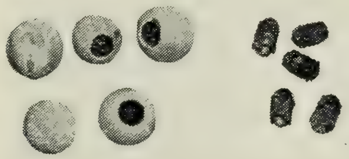

Fig. 37.—Pea weevils and their work, natural size.

Life History and Injury.—The beetles emerge from their winter-quarters in spring about the time field peas are ordinarily coming into bloom. They feed a little on the blossoms or stems and then lay their yellow eggs upon the pods soon after these are formed. The larvae on hatching bore through the pods and enter the tiny peas. The entrance holes soon heal over and the larvae feed in concealment until full grown; then they pupate just where they are. By the time the peas are ready to harvest the pupae have changed into adults, each pea containing only one adult. The great mass of the adults remain over winter in the peas, concealed from view, though the darker colour above their chamber reveals their presence. Some of the beetles, however, leave the peas in the field. These winter over outside in any good shelter that they can find. Others come out of peas in the barn, most of them at the time of threshing. These winter over in or around the barn.

As infested peas have half or nearly half the interior eaten, their food value is greatly lessened. Moreover, a high percentage of them either will not germinate or will produce weak plants; hence it is easily seen that if half or, as often happens, much more than half of the seed is infested the loss to the grower is great.

Control.—1. All infested peas should be cut or pulled as soon as they are ripe, or preferably while they are still a little on the green side, and should, as soon as they are dry, be gathered carefully and threshed at once. After threshing all the seed should be fumigated promptly while the weather is still warm, with carbon bisulphide. (For methods of doing this, see under "Bean Weevil," page 20).

2. Hogs should be allowed to run in pea fields after removal of the peas, as they will eat many of the infested seed and thereby help lessen the number of weevils which will winter over.

3. Infested peas, even though there are few weevils in them, should never be sown without first destroying the weevils by fumigation. If, however, the seed has been kept for two years in tight bags, the weevils present will have come out, and being unable to escape will by this time be dead, so that such seed may safely be sown.

4. If weevils are very bad in any community that community should cease growing peas for a year. This will result in the destruction of all the weevils in the district and the farmer can then start off afresh, but should be careful to see that all the seed sown has first been fumigated.

5. Though our winters do not kill all pea weevils as they do bean weevils, if exposed, yet they destroy a great many of them, and it has been noted often that the colder the district the lighter the infestation from this pest. It would appear, therefore, as if pea growing might be carried on with greater success so far as the pea weevil is concerned in New Ontario, than in any other part of the province.

Pea Aphid

Illinoia pisi Kalt

The pea aphis is light green in colour and about $\frac{1}{8}$ inch long. Like other aphids it is sluggish in movement and has sharp mouthparts with which it pierces through the surface of its food plants and extracts the juices from within.

Food Plants.—Peas—including sweet peas—are the favourites. In addition clover—including sweet clover,—alfalfa and vetches, are attacked.

Injury.—The injury takes place chiefly from about the time the peas are coming into bloom until they are nearly ready to harvest. The aphids during this period sometimes attack them in so great numbers that they almost cover the plants, and by sucking out the juice of the leaves, stems and blossoms soon cause the plants to turn yellow and die before the seed is nearly mature. In this way in a season favourable for the aphids, the greater part of the crop may be ruined over large areas. Every field, however, will not suffer equally, because of difference either in time of planting or of proximity to clover, or because of moisture or other natural factors which play a great part in determining the abundance or scarcity of the insect.

Life History.—The winter is passed in the egg stage chiefly on clover and probably to a lesser extent on alfalfa and vetch. The eggs hatch in spring about the time growth has clearly begun. The aphids feed upon the winter host plants for a considerable time. Then winged forms are produced which fly chiefly to peas but also to some extent to alfalfa and vetch. When the peas are ripe many of the aphids perish but the winged ones migrate either to late peas, if any, or to clover or other food plants.

Control.—1. Plant peas early, as late peas suffer much worse than early.

2. If practicable, plant them at a considerable distance from clover, as the closer they are to the clover, the more likely they are to become heavily infested.

3. Garden peas grown in rows can be saved by dusting them thoroughly with 2 to 3% nicotine dust as soon as the aphids are seen to be abundant. Do the dusting in the heat of a warm calm day and, if a power duster is used, attach a trailer of cotton or of some other light cloth behind to concentrate the dust.

4. Spraying with nicotine sulphate 40% at a strength of ⅜ pint to 40 gallons of water may be substituted for dusting, especially in the case of sweet peas or of small garden areas of field or table peas.

INSECTS ATTACKING POTATOES, TOMATOES AND EGG PLANTS

The Colorado Potato Beetle

Leptinotarsa decemlineata Say

There is scarcely any insect better known to farmers and vegetable growers than the Colorado potato beetle. It occurs in every part of the province where potatoes are grown, being even up in New Ontario. Everywhere it is the most destructive insect pest of potatoes and is often so abundant that a great part of the crop would be almost ruined if the plants were not protected by spraying or dusting. Some years, however, it is so reduced in numbers by unfavourable weather conditions, predaceous enemies and parasites that very little damage takes place even though no control measures are used.

Food Plants.—Potatoes are much preferred to any other plant but it is not uncommon to find tomatoes, egg plants and the common nightshade (Solanum nigrum) also attacked though to a much less extent than potatoes.

Life History.—The winter is passed in the adult stage beneath the surface of the ground in the same field or plot where the beetles fed during the preceding summer. The depth to which they go varies from about 2 to 18 inches, large numbers being near enough to the surface to be turned up by the plough in fall or early spring. Towards the end of May the beetles emerge and soon fly away in search of potato plants. On finding these, they at once proceed to feed, mate and lay eggs. Egg-laying continues at intervals for a month or more. A single female may lay at least 1,000 eggs, but the average is probably less than half this number. The eggs are oval in shape, yellow to nearly orange in colour and are usually placed in clusters of about 5 to 150 each on the underside of the leaves. The incubation period is approximately one week.

The larvae soon after hatching begin to feed upon the leaves and eat small areas out of them. As they approach maturity they do much more damage and quickly strip the plants of all their foliage, leaving only the stem and main branches.

It requires from two to three weeks for a larva to become full grown. It then enters the ground from 1 to 6 inches, transforms there into a pupa and in a week or a little more, emerges as a beetle.

Many of these new beetles, especially of those that emerge earliest, lay eggs and produce a second generation, but a large number, especially of the later emerging ones, do not lay eggs but merely feed a while and then enter the soil for winter. The larvae of the new generation pupate in the soil and change into adults. These like the other adults which did not lay eggs, feed for some time and then they too enter the ground for winter. Thus we have in Ontario one full generation and a partial second one.

It is interesting to know that while most of the beetles which appear in the spring die before winter a number of them live through a second winter and even lay fertile eggs the next spring.

Control.—A few growers protect their plants by picking off the beetles but this is such a slow labourious process that spraying or dusting has come to be the regular method of control. Whichever of these two methods is used it should be applied as soon as the eggs have begun to hatch, because the larvae are much more easily killed while small than later and by destroying them early the plants are saved from the injury that would take place.

The best mixture to use is 1½ to 2 pounds arsenate of lime (calcium arsenate) to 40 gallons of Bordeaux mixture (4, 6, 40 formula). The arsenate of lime may be used with water instead of Bordeaux, but in this case it is perhaps wise to add about 2 pounds of hydrated lime to guard against possible burning. It is better, however, to use the Bordeaux, because it not only helps ward off fungus diseases such as late blight, but also repels the leaf-hoppers and flea-beetles and keeps the plants more vigorous, thus increasing the yield.

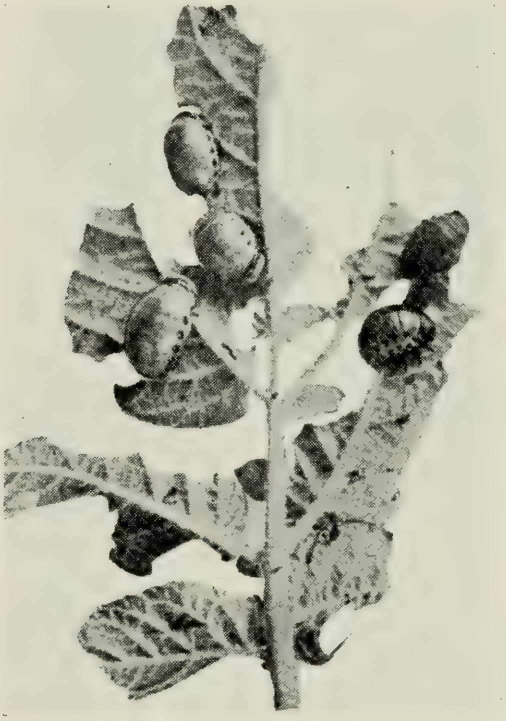

Fig. 38.—Colorado potato beetle larvae feeding on potato leaves, natural size. (Adapted from Britton).

Arsenate of lead, 2 to 3 pounds to 40 gallons, may be substituted for the arsenate of lime, but is much costlier and kills more slowly.

Paris green, 1 to 2 pounds, is another substitute but it also is dearer than arsenate of lime and washes off much more quickly than either it or arsenate of lead.

A fourth substitute is 1 pound arsenate of lead and 1 pound Paris green. This is quite effective but is much dearer than the arsenate of lime and gives no better results.

The most common dust is a Bordeaux-arsenate of lime mixture, the common formula for which is 12 pounds dehydrated bluestone, 80 pounds hydrated lime and 8 pounds of arsenate of lime. This dust by having the bluestone and lime in it, acts as a fungicide as well as an insecticide. If for any reason it cannot be secured a good dust against the beetles may be made of 1 pound of arsenate of lime mixed with 10 pounds of hydrated lime. This, of course, is not a fungicide. Dusting should be done when there is no wind and preferably when the plants are moist, as from dew or recent rain.

In either dusting or spraying the plants should be covered thoroughly, even if this means having to go over them twice on the same day.

Usually two thorough sprayings or dustings, one, as mentioned, when the eggs begin to hatch and the other as soon as the larvae again begin to be abundant, will give satisfactory control, but some years itis necessary to give an extra treatment a week or so later. The main thing to remember is to get the first application on early and thoroughly and never allow the insect a chance to get a good start.

POTATO FLEA-BEETLE

Epitrix cucumeris Harris

The potato flea-beetle is a small insect, not larger than the head of a common pin, with a black body and yellowish-brown legs and antennae.

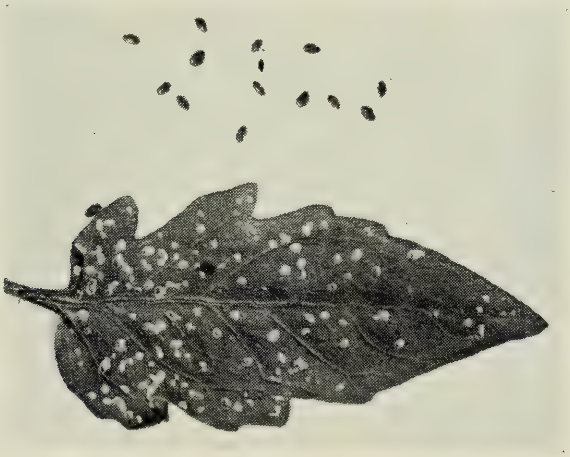

Fig. 39.—Potato flea-beetle—adults and injury, natural size.

The larvae are slender white worms with brown heads. When full grown they are about ⅕ inch long. Very few people ever see them because they remain underground all the time.

Injury.—Although not so destructive as the Colorado potato beetle, the flea-beetle is one of our important potato pests. It is also some years quite injurious to tomatoes during the first week or two after the young plants have been set out. By far the greater part of the damage is done by the beetles themselves. These feed upon the leaves of potatoes and tomatoes in May and June and when abundant make so many small holes in them that the leaves are greatly weakened and sometimes turn brown and dry out. Later in the season in August and September, potato leaves may sometimes again be attacked and severely riddled, though tomatoes are seldom fed upon at this time.

The larvae in this province have caused very little damage. They feed in the soil upon the roots of potatoes and to some extent of other plants too and perhaps also upon decaying vegetable matter. Occasionally they attack the tubers and make little tunnels in them or cause pimply growths upon the surface.

Life History.—The winter is passed in the adult stage under leaves, rubbish or any other kind of good shelter. In May the beetles come forth and may be found on the foliage of many kinds of weeds and other plants, though they seem to feed very little on these. As soon as potatoes or tomatoes are available they fly to them and feed as described above. Egg-laying takes place in June and early July. The eggs are very small and white and are laid singly in the soil. The larvae on hatching feed as described above. When full-grown they pupate in the soil. From the pupae new beetles begin to emerge in late July and become most numerous about the first week in September. These feed upon the foliage until cold weather drives them into winter quarters. There is apparently only one generation a year.

Control.—This insect is easily controlled. All that is necessary is to spray thoroughly with Bordeaux mixture 4, 6, 40 formula as soon as the plants are seen to be attacked and repeat if necessary in about 12 days. The Bordeaux must be applied to both sides of the leaves as the beetles feed on both. Poison is not necessary but may be added to destroy the Colorado potato beetle, if this is present.

Dusting with Bordeaux does not seem to give nearly so satisfactory results as spraying.

POTATO LEAF-HOPPER

Empoasca mali Le Baron

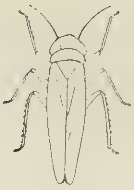

Fig. 40.—Potato leaf-hopper adult, greatly enlarged. (R. Ozburn.)

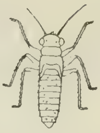

Fig. 41.—Potato leaf-hopper nymph, greatly enlarged. (R. Ozburn.)

The potato leaf-hopper is a very small, green, sucking insect which both in the adult and nymph, or immature stages, feeds almost entirely on the under side of the leaves of potatoes. Here it pierces the tissues with its sharp beak and extracts the juice. When very abundant it may injure the plants considerably through the loss of juice. The main damage, however, is done in a very different way; namely, by the insect inserting a poison into the part where it feeds. This causes the leaves to turn yellow along the margin, usually at the tip first. Then the margin gradually turns brown and curls upwards and inwards. Often every leaf is thus affected, with the result that the entire plant soon dies. Whole fields some years are blighted in this way. This type of injury is called "hopperburn." Most of the disease which farmers previously called early blight or tipburn has now been proven to be hopperburn. Hot dry weather may be said to favour the disease but chiefly because it favours the growth and increase of the leaf-hoppers.

The adult leaf-hoppers are only about one-eighth of an inch long and are pale green with a few white markings, chiefly on the head and thorax. They leap and fly quickly.

The nymphs just after hatching from the egg are white to whitish green and so small that they look like a mere dot. As they grow older and larger they become pale green. They are much the same shape as the adults but have no wings and are smaller and paler in colour. They seldom leap but if disturbed run quickly to shelter.

How to distinguish leaf-hoppers from green potato aphids.—Both have the same habit of piercing the leaves and sucking the juices but while the leaf-hoppers confine themselves almost entirely to the underside of the leaves, the aphids cluster not only on the under side but also on the leaf stem and tender upper portions of the plants. When disturbed they move very slowly compared with the rapid movements of the leaf-hoppers. Aphids are also much broader and stouter in proportion to their length than leaf-hoppers and have a pair of little horn-like tubes towards the rear end of the body. Most of them have no wings, even in the adult stage.

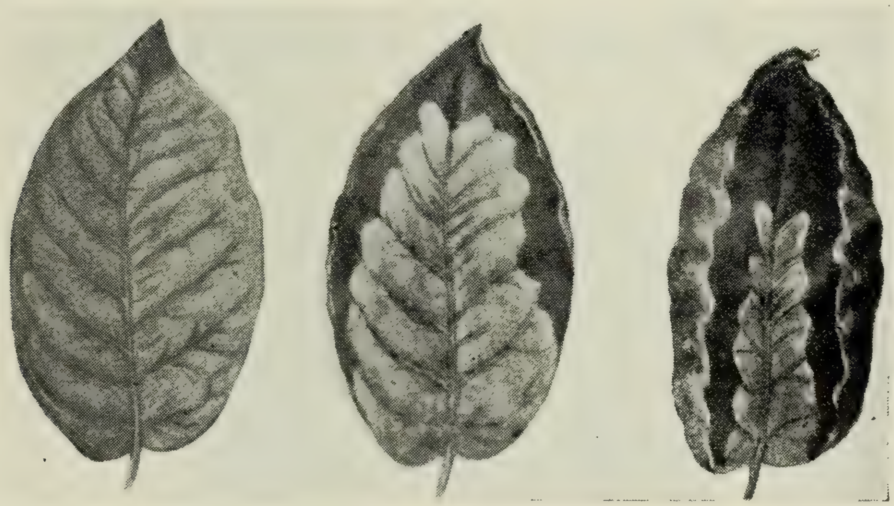

Fig. 42.—Hopperburn—injury to potato leaves, caused by potato leaf hopper adults and nymphs. (After Fenton and Hertzel.)

Food Plants.—Potatoes seem to be the favourite food plants of the leaf-hoppers, but they breed freely also on beans, sugar beets, raspberries, apples, and to a lesser extent on several other plants.

Life History.—The winter is passed in the adult stage in weedy or grassy places or among brush or rubbish of any kind where they can find good shelter. In spring, soon after vegetation has well begun, they come out of their hiding places and feed on weeds or other plants until potatoes are far enough advanced to give them an abundance of food. Then they migrate to these and also to some extent to the other host plants mentioned above. Soon after migrating, they lay their eggs on the leaf stems and leaf veins. The eggs are small and white and are inserted so deeply in the tissues that they are not visible. Egg-laying continues for a month or more. The eggs hatch in about 12 days and in 2 weeks or a little more the nymphs become full grown and change into adults. This new brood of adults appears in late July and early August. Eggs are then laid during several weeks for another generation. There are thus two generations a year or at least one full generation and a partial second. As implied above, no nymphs but only the adults winter over. During the summer it is customary for the adults to migrate from a field of old or dying potatoes to a field of healthy late planted ones.

Control.—Spraying the plants with Bordeaux mixture 4, 6, 40 formula (see page 4) will give good control. The spray, however, must be applied to the underside of the leaves, because the insects feed there. It must also be done thoroughly, so that all the underside will be completely covered. The Bordeaux destroys the nymphs and drives the adults away. The first spray should be when the leaf-hoppers begin to attack the plants, which will usually be when they are about 4 inches high; the second in 10 to 12 days and the third after the same interval. Poison is not needed with the Bordeaux for the leaf-hoppers, but should of course be added to the first and second applications for the Colorado potato beetle.

Fortunately, Bordeaux mixture will not only control the leaf-hoppers but also the flea-beetles and the late blight disease. For the last of these more applications have to be given in a wet season.

POTATO APHIDS

Several species of aphids attack potatoes but far the most common are the so-called "potato aphid" (Macrosiphum solanifolii Ashmead) and the peach or spinach aphid (Myzus persicae Sulzer). Most individuals of both species are green but some, especially of the former, are pink. They are small insects ⅙ inch long or less.

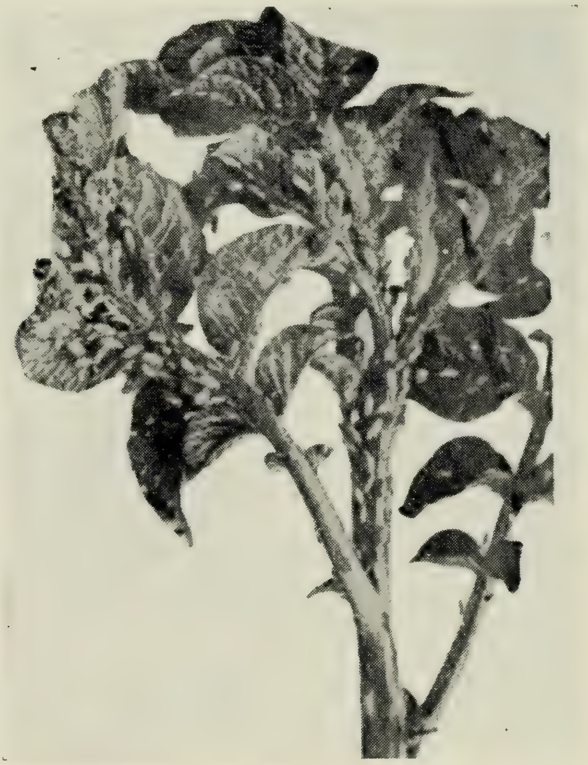

Fig. 43.—Potato aphids. (After Britton).

Life History.—Throughout the growing season all the aphids are females and all produce living young. As there are many generations in a season, reproduction is very rapid when weather conditions or absence of natural enemies permit. Usually both winged and wingless forms are present. The latter often fly to other potato fields or to weeds or other vegetables and feed and breed there. In the fall of the year the first species mentioned above migrates to rose bushes, lays its eggs on them and passes the winter there in the egg stage. The other species flies chiefly to peach trees and winters on these in the egg stage. In spring the eggs of both hatch about the time the buds are bursting. After feeding a couple of weeks on their respective winter hosts, both species produce winged forms which fly back to potatoes and to some extent to other plants, many of the peach aphids to spinach.

Injury.—Aphids have very fine, sharp, piercing mouthparts, which they insert into the leaves and tender stems of the potatoes and suck out the juice. When abundant they nearly cover the plants and are specially numerous on the under side of the leaves. Under such circumstances the great amount of juice extracted causes the leaves to become a sickly yellow colour and often to die. However it is only rarely in this province that potatoes are killed or even greatly weakened by aphids. The chief damage they do is of an entirely different nature; namely, the transmitting of two common potato diseases—mosaic and leaf roll. These diseases are introduced through the seed but once in the field spread from plant to plant only by means of aphids. The aphids get the virus of the diseases into their body by feeding on diseased plants and when they insert their beak into a healthy plant they inject some of this virus into it and thereby inoculate the plant.

Control.—It is comparatively seldom that potato aphids are so abundant in Ontario as to require any artificial control measures. Wherever treatment is necessary the best method is to dust the plants thoroughly both from above and below with a two per cent. nicotine dust made by mixing together five pounds nicotine sulphate 40 per cent. and 95 pounds hydrated lime. The dusting should be done on a warm calm day. Spraying with one pint of nicotine sulphate 40 per cent., five pounds soap or one pound calcium caseinate to 100 gallons of water or of Bordeaux mixture is fairly satisfactory if applied well to both surfaces of the leaves, but it is not so effective as the dust.

It is impossible to annihilate aphids in any potato plot because the insects breed as said above on many other kinds of plants and will fly in from these and thus reinfest the potatoes. For this reason and also from the fact that the cost of dusting or spraying for aphids is high the best way to control mosaic and leaf roll is by careful inspection and roguing of fields and by planting only certified seed.

As one species of potato aphid winters on rosebushes it stands to reason that, if rosebushes were sprayed with nicotine in spring when their buds are bursting or soon after, this would lessen the number of aphids that would fly from the rose to the potato.

BLISTER BEETLES

Blister beetles are large, rather slender, nearly cylindrical beetles. They are about two-thirds of an inch long and about one-sixth of an inch thick. There are at least three species in Ontario which at times attack potatoes: namely, the black (Epicauta pennsylvanica DeGeer), the ash-grey (Macrobasis unicolour Kirby), and the striped (Epicauta vittata Fabricius). Of these three the black is much the most common in old Ontario at least and may readily be seen feeding on goldenrod flowers almost any year in August and September.

Injury.—The adults do all the damage, the larvae being considered beneficial as they feed largely upon grasshopper eggs. Potatoes are the chief cultivated crop which is injured, but the beetles feed also at times upon many other cultivated plants and upon the leaves and flowers of many wild plants. Injury to potatoes in the writer's experience is most common in districts where there is much waste land or where woods have been cut over or burned. In such places the beetles sometimes in great swarms attack the plants and do great damage by eating large areas out of the leaves or even by completely defoliating the plants. Injury, however, is seldom general in any district, as usually it is only a field here and there which is attacked. Sometimes, too, the beetles feed only for a short time in one field and then fly away to another.

Life History.—As the life history is too complex to give here in detail it will suffice to say that the beetles are present from June or July on into September. The eggs are laid in the ground. The larvae are very active and search out and devour grasshopper eggs though they doubtless feed also on other things. The winter is passed in the soil in the nearly mature larval stage. Pupation takes place in spring and adults appear in June or July. Thus there is ony one generation a year.

Control.—Experiments in Louisiana in 1925 on dusting the beetles on Soy beans showed that sodium fluosilicate either alone or mixed with equal parts of hydrated lime not only caused the beetles to cease feeding almost at once but also killed almost 100 per cent. of them. Though these experiments were carried out on a different species of blister beetle there is very little doubt that our species would be just as susceptible to this poison. (For further information on sodium fluosilicate see page 3).

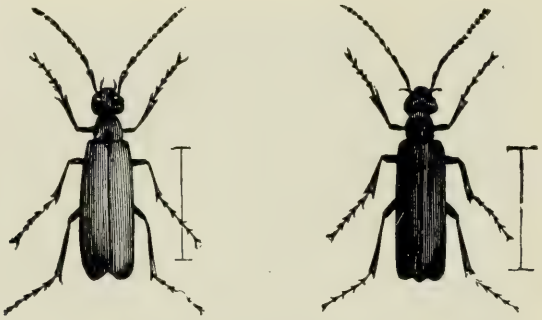

Fig. 44.—Blister beetles, enlarged, the line to the right shows natural size.

Spraying infested plants with two pounds arsenate of lead or one-and-a-half pounds arsenate of lime or one pound Paris green to 40 gallons of water or of Bordeaux mixture drives the beetles away but it is doubtful if it kills them. Dusting may be substituted for spraying. In that case dilute each pound of the arsenate of lead with about five pounds hydrated lime, of the arsenate of lime with about seven pounds and of the Paris green with about ten pounds.

Tomato Worm

Phlegethontius quinquemaculata Haworth

The tomato worm is the large green worm with a horn at the posterior end which is often found eating the leaves of tomatoes and of tobacco. These worms when full-grown are sometimes four inches long and about half an inch in thickness. Along each side of the body there is a row of large V-shaped white markings which distinguish this species from others looking much like it. The worms are nearly the same colour as the leaves and so are often difficult to see. As a rule they are not very abundant but some years there are sufficient of them to defoliate many plants.

The adults are large hawk-moths which fly around in the evening and at night, insert their long, slender, sucking tube into the flowers of tobacco, thorn-apple or other plants with long, tubular, bell-shaped flowers and suck the nectar out of them. The wing expanse of the moth is from four to five inches. The upper wings are grey marked with irregular black lines. The hind wings are whitish grey with a broad margin of grey and with heavy wavy black bands across them. The body is grey, spindle-shaped, stout and one-and-a-half to two inches long. On each side there is a row of five large yellow spots margined with black.

Life History.—The moths appear in June and lay their yellowish green eggs singly on the leaves, usually on the under side. The eggs hatch in about a week and the larvae become full grown inside of a month. They then enter the ground, make an earthen cell and pupate. The pupa is dark brown, about two inches long and half an inch thick and has a conspicuous handle-like structure at one end, which in the moth becomes the proboscis or sucking tube. The winter is passed in the pupal stage. Normally there is only one generation a year but sometimes in a warm season in the south-western part of the province there may be a partial second generation.

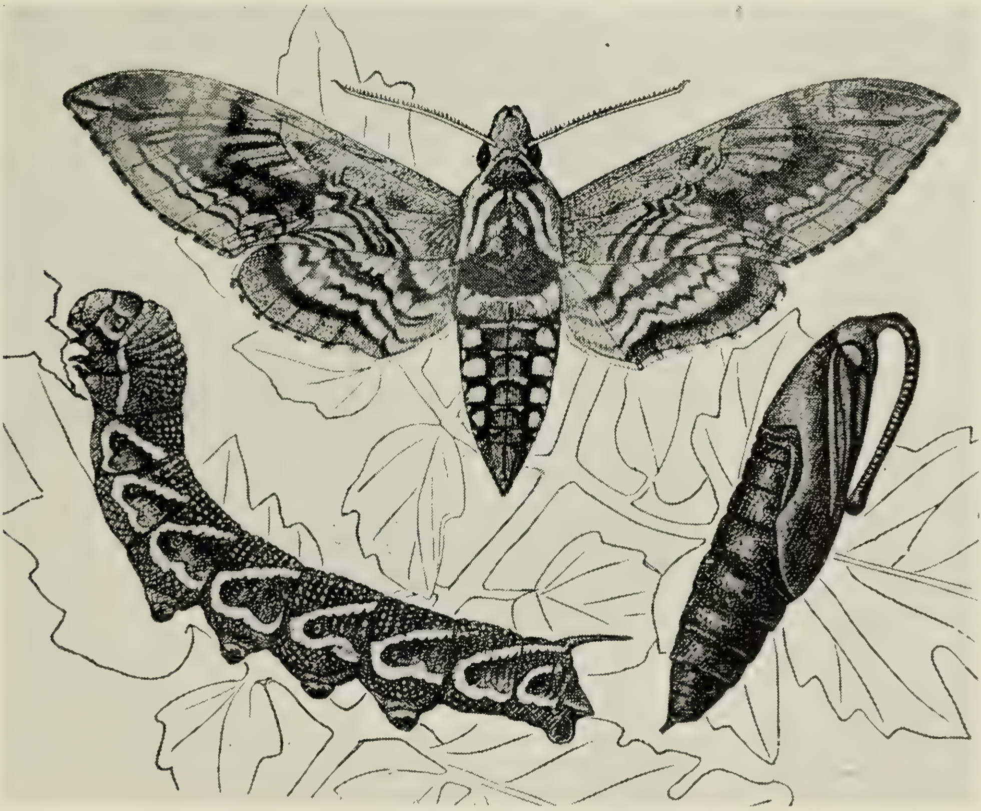

Fig. 45.—Tomato worm—adult, larva and pupa. (After Howard, U.S.D.A.)

Control.—The usual method of control is to pick off the larvae by hand and kill them. If, however, they are seen to be too numerous for this they should be sprayed at once with two or three pounds of arsenate of lead or one-and-a-half pounds calcium arsenate or one pound Paris green to 40 gallons of water.

Dusting may be substituted for spraying, the arsenate of lead being diluted with two or three times its own weight of hydrated lime, the arsenate of lime with three or four times its weight and the Paris green with five or six times.

RHUBARB INSECTS

The Rhubarb Curculio

Lixus concavus Say.

The rhubarb curculio is a large slaty-black beetle with a long snout, is about two-thirds of an inch in length and can readily be recognized by its large size, long snout and the yellow powder which in nature covers its body.

The larva is white, stout and about three-quarters of an inch long when full grown. It is legless and has a brown head.

Food Plants.—In addition to rhubarb the beetle attacks curled dock and in some places also thistles and sunflowers but the writer has found it in this province only on rhubarb and dock.

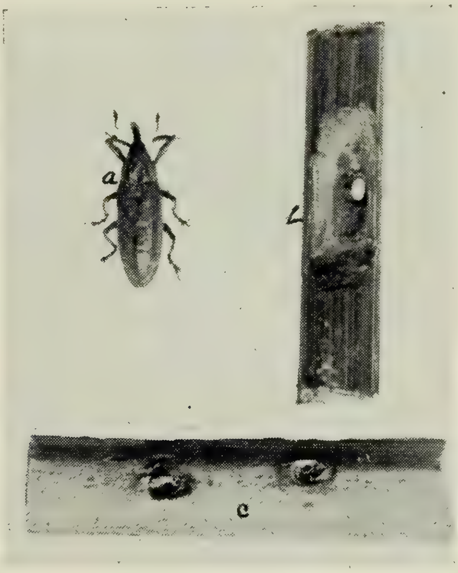

Fig. 46.—Rhubarb curculio—(*a*) adult; (*b*) egg in curled dock, the surface being removed to reveal it; (*c*) feeding and egg-laying injury in curled dock; all natural size.

Injury.—The injury to rhubarb is caused by the beetles alone; for the larvae in these plants die very soon after hatching from the eggs, probably because of the great amount of acid present. The beetles during June and early July eat oval or round holes about one-eighth of an inch deep in the stems and leaf ribs. This is done for feeding and egg-laying purposes. Gum usually exudes from these holes and in most cases the affected area dries out and turns brown, though occasionally rot may set in. Often there are a dozen or more injured places on a single stem. The resulting scars make the stems unsightly and unsaleable. Fortunately the marketing season is nearly over before the beetles begin to attack the plants. Severely infested plants frequently are so weakened that they break off with heavy winds. Injury in commercial plantations is usually rare but is not uncommon on rhubarb plots on farms or in gardens in villages and towns wherever docks are growing in the vicinity of the rhubarb.

Life History.—The beetles begin to appear and attack the rhubarb and docks about the beginning of June. In a short time egg laying commences and continues for a little over a month. The larvae from the eggs laid in rhubarb, as mentioned above, die before they do any damage but from the eggs in docks they live and soon bore down through the stem to the ground. Here they continue to feed until full grown, then change into pupae and about September the new beetles begin to emerge. These, after feeding a short time, go into winter quarters, apparently under rubbish or leaves in the vicinity.

Control.—As the insect breeds entirely, or almost entirely, in docks the simplest method of combating it is to prevent docks from growing in the neighbourhood of rhubarb. If the beetles are present and attacking rhubarb it is a good plan to leave the docks until all eggs are laid, which will be about July 15th and then cut the plants with a spade or weed spudder several inches below the ground so as to be below where the larvae are situated. Then gather the docks and burn them as soon as they are dry.

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Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

FARM BARNS

By E. W. Kendall, B.S.A., Associate Professor in Agricultural Engineering.

AND

L. Stevenson M.S. Director of Extension.

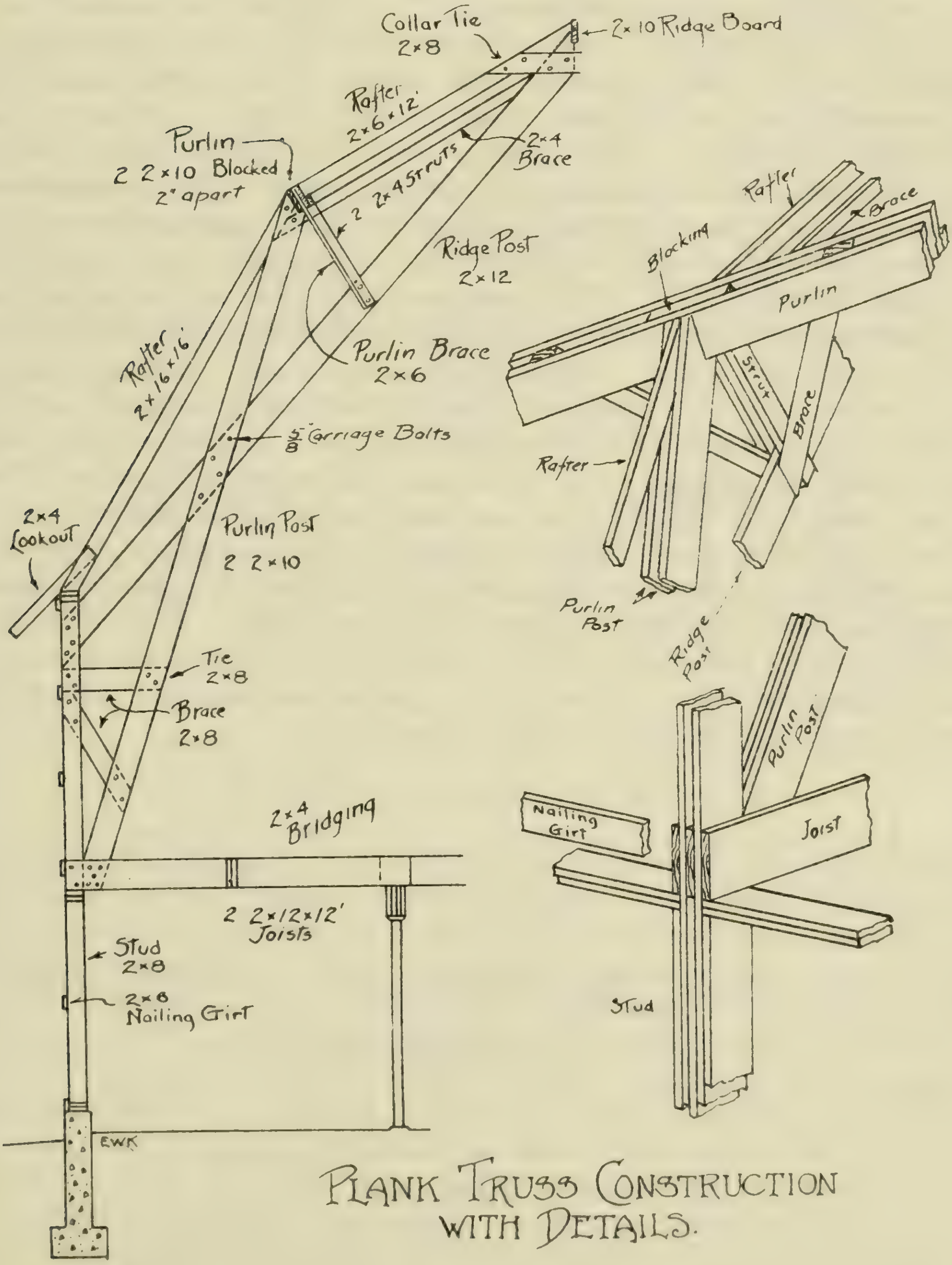


Fig. 1

FARM BARNS

The changing ideals in Ontario's agriculture have worked an evolution in farm buildings. The old type barn of grand-dad's day, traditional in plan and construction, served its purpose well. But the crystallization of modern farm ideas, as evidenced in new farm organization, new crops, improved stock, machinery and world-wide markets for staple products, has brought with it a type of building designed to be directly adapted to the use for which it is constructed.

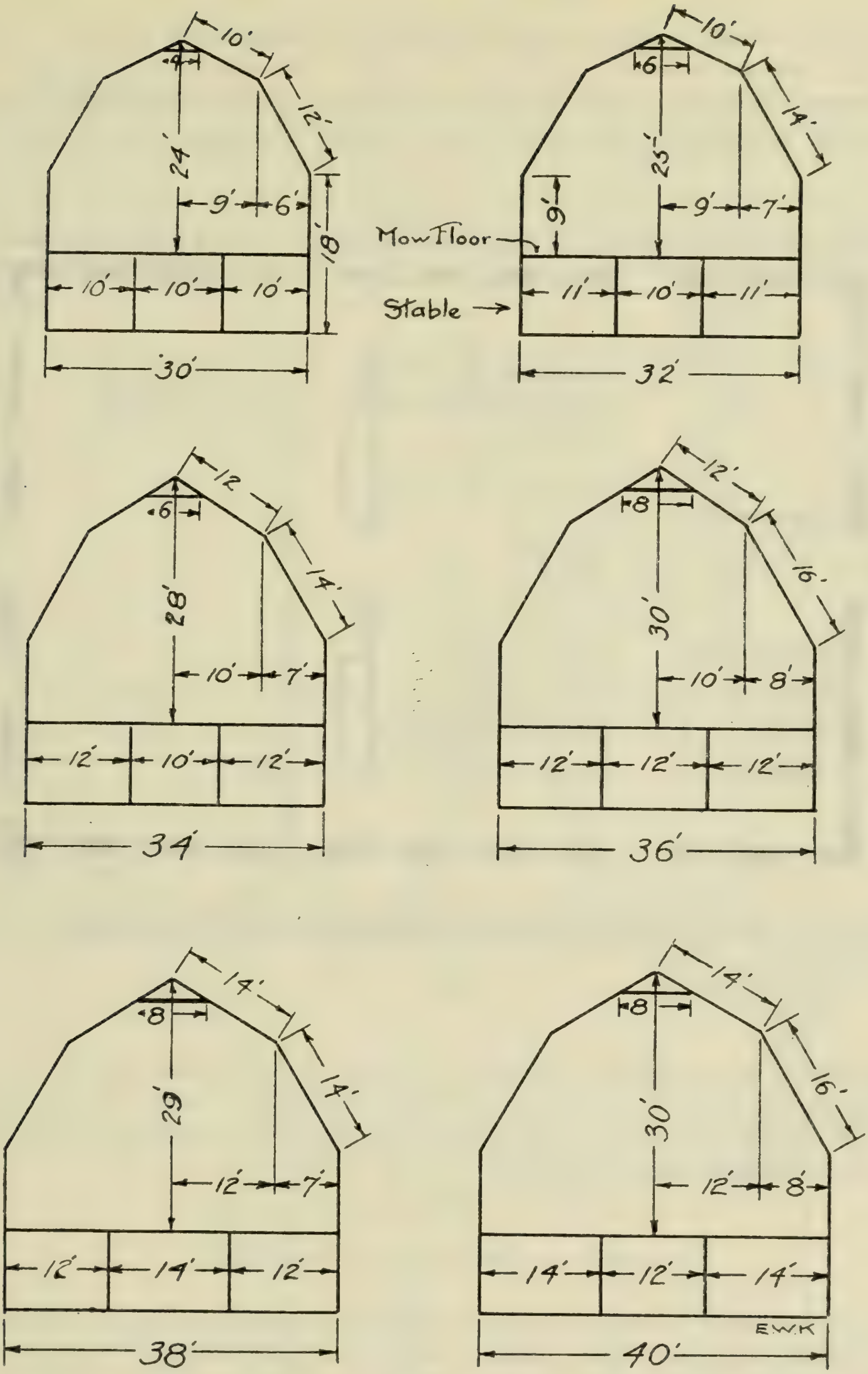
Ontario farms are as well equipped with buildings as are the farms of any other province; however, true as this is, we still have some old barns and judging from the enquiry asking information on the structure of farm buildings, many farm people are interested both on the old and new farm lands of the province.

Planning

In planning any farm building consideration must be given to the three main objects; (1) to evolve a plan that will result in a building that will give the service for which the structure is desired; (2) to provide for economy in labour, time and effort in getting the farm work done; (3) to provide conditions of comfort and well being for the animals housed therein or the people doing the work. Farmers generally are getting away from the old tendency, to put up numerous small buildings far apart. The waste of time and labour doing the work in scattered buildings, as compared with the efficiency of the centralized plan, would figure out at "years of time" during the life of the farmer or the period of usefulness for well-constructed buildings. However high costs of building and slim bank balances have to be considered and some well-informed, practical business farmers doubt the wisdom of large expenditures to shelter products of low value, as hay and straw. These men maintain that cheaper structures for storage of winter feed are desirable from a business standpoint and for that reason make full use of machinery for the reduction of coarse feeds to a dimension that will permit the storage of a lot of material in a small space. The straw cutter, hay press, and silage cutter are machines that aid to this end. Inexpensive hay and straw sheds, that are simply well constructed shells on a good foundation will protect these feeds quite as well as the big expensive truss frame barn costing as much in some instances as the farm lands. With little likelihood of building material becoming lower in price, the tendency should be towards buildings of moderate size, planned for a special purpose and full efficiency in giving satisfactory shelter at the lowest possible cost.

Plan Your Barn

Develop on paper a sketch that will give you a mental picture of what you want, keeping in mind that a conveniently arranged barn will save you both time and money, every day in the year, during your farming life-time. You know how many tons of hay, how many bushels of grain, your farm can produce and for which shelter must be provided. You know how many horses and how many cattle you want to keep, and for what purpose, beef or dairy. No one else knows these things as well as you do. So your farm with its peculiarities and you with your desires and inclinations as to the type of farming to be followed, will determine the type of structure, its size and interior arrangement. Don't experiment with carpenters and building material, it costs too much. Changes are difficult to make and very expensive. Make your changes on the paper plan, before the builder starts to work, not after. Paper is cheap and the winter evenings are long, so get the plan right.

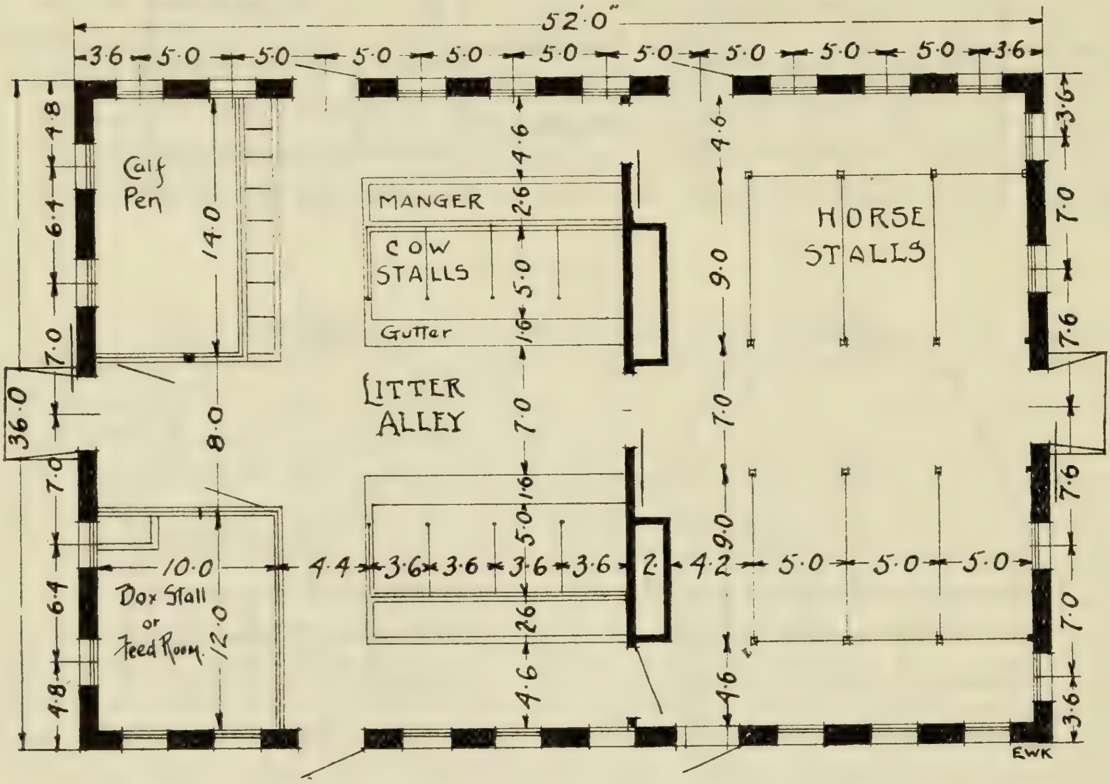


Some General Dimensions for Barns of Various Widths.

Fig. 2.

LOCATING THE BARN

There are a number of factors to consider, the location of the dwelling house or houses in which the farm men live, the slope of the ground, the water supply and the prevailing winds. The barn should be at least 200 feet from the dwelling and on lower ground, that drainage may not be towards the house. Prevailing winds carry odours from the stable and yard. The water supply may also be contaminated from the yard drainage and should be considered before the final location is decided. A gentle slope to give drainage away from the barn is desired and if not naturally supplied, drainage must be provided by tile, ditch or dyke in order that the yard may be kept reasonably dry, Barns located on or near the highway have an advantage if much road hauling is to be done in connection with the farm business.



AN ILLUSTRATION of the COMMON STABLE MEASUREMENTS.

Fig. 3.

Position in Relation to the Sun

North and south barns are more favourably placed in so far as the important factor of sunlight is concerned, than those set east and west. The barn set with its end toward the east can at best get direct sunlight on two ends and one side during the day. While the barn set north and south gets direct light on two sides and one end. Direct sunlight is important, in that the sun's rays destroy disease-producing organisms, and aid materially in the animal mineral metabolism. With the barn placed right in relation to the sun, a window that will permit the passage of all the sun's rays should only be considered. Sunlight is the cheapest of disinfectants, so let it in through windows that have the longer dimensions up and down. Six lights, eight by twelve to a sash, gives four square feet of glass surface per cow, which is about the minimum for an animal and maximum for a strong structure. A window sash containing six eight by twelve lights will fit between wall studding placed two feet apart. Keep this in mind when making your plan.

Interior Arrangement of the Stable

For cattle, double rows of stalls running the long way gives greatest efficiency in the utilization of space and labour. There is considerable loss of both space and labour where several rows of stalls extend across the stable. Too much walking and carrying to do the work, too many doors and too much space at the ends of the stall rows. So make your plan, double stall rows running the long way of the stable.

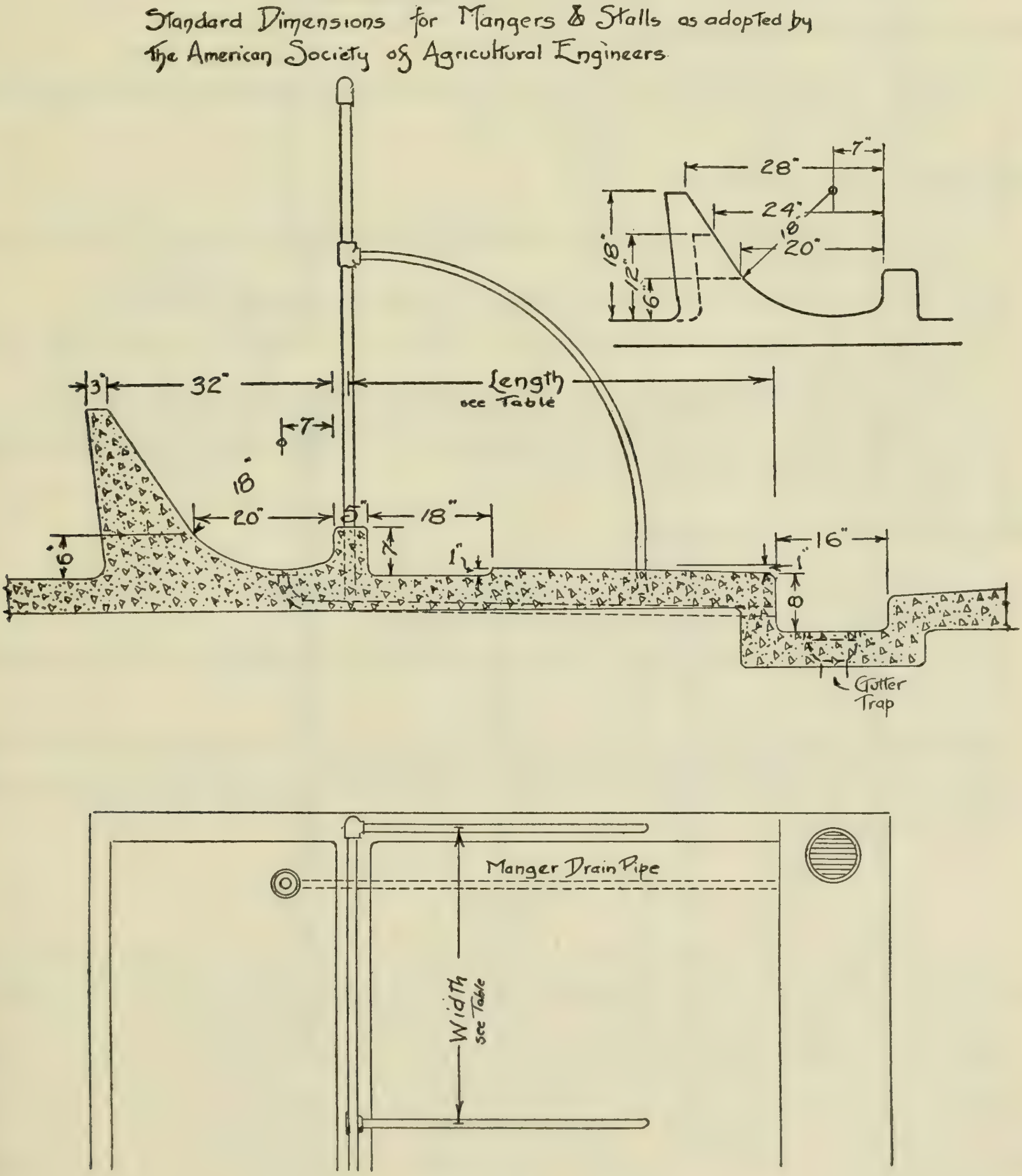


Fig. 4.

SHALL WE FACE THE CATTLE IN OR OUT?

Both arrangements have their advantages and disadvantages, as follows:—

Cattle facing in—advantages.

1. Easier to feed and the labour of feeding is a big part in cattle maintenance cost.
2. Tail end of cow toward the light, which aids in keeping cattle clean, better light for the milkers, direct rays of the sun strike the gutter.
3. Ventilation easier.

Cattle facing in—disadvantages:

1. More labour to clean out, where there are two gutters widely separated, more trackage for the litter carrier.

Cattle facing out—advantages:

1. Easier to keep the walls clean as all manure is to the centre of the stable away from the walls.
2. Gives better appearance as the cattle can be viewed together.
3. Saving in doors, as one end door serves to clean the stable and let the cattle in or out.
4. Sunlight on the mangers, more important than on the gutters.
5. Easier to remove manure with wide central drive, as the manure spreader can be loaded at once.

Cattle facing out—disadvantages:

1. Light on the head end of animal not so important.
2. Feed has to be moved farther in feeding.
3. If cattle get loose, may injure all, whereas if facing in, will be confined to one side.

The advantages either way are about equal and as the same thirty-six feet of width accommodates both systems it matters little in the last analysis which way the cattle face, the advantages of one balance those of the other.

FLOORS

A good floor is very important. It should be sound, of proper grade, hard, smooth enough to be easily cleaned and dry enough to be warm. Concrete is the best floor. The tie-stall floor space should be overlaid with planking, that has been creosoted, sized to fit tightly at the edges and flat on the concrete. Box stalls, calf pens, feed alleys, passages and walks should be finished just rough enough to prevent slipping. Frosted concrete and frosted hoofs are a bad combination, so walks where cattle tread going in and out of the stable should be deeply marked to give footing. All floor grades should be correct and as firm as such can be made before the concrete layer is put down. Floors should not be less than four inches thick at any point, while gutter edges and walks where the weight of crowding cattle may be great at times, should be six inches thick. The green concrete should be well tamped with a heavy iron tamper before the surface goes on. This will offset settling and cracks. It pays to get the underneath solid before the concrete is put down as a cracked, sagged floor can only be made satisfactory by doing all the work over again. So do it well.

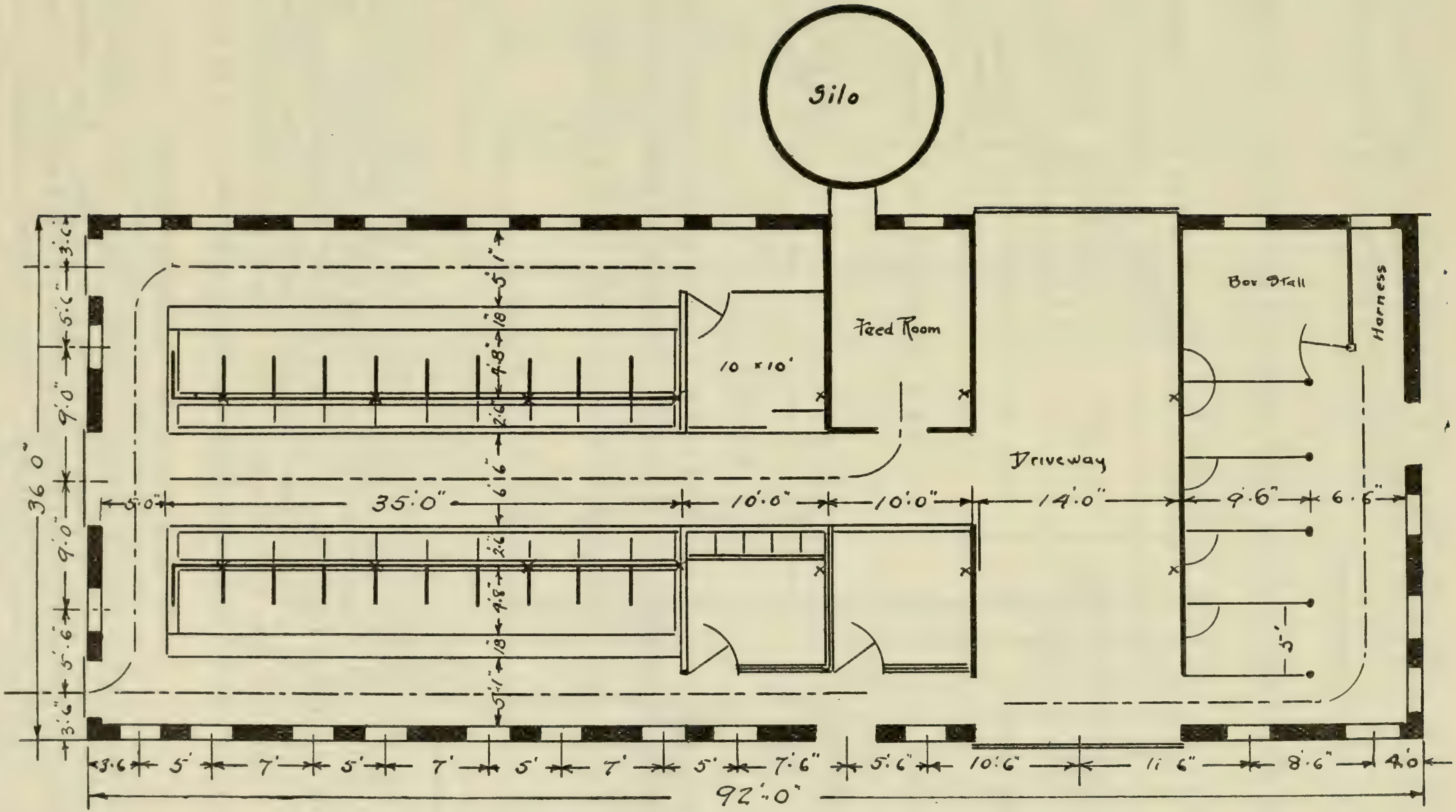


Fig. 4A—Showing good stable arrangement for a general purpose barn.

STALLS

A big cow needs a big stall. Big stalls are very unsatisfactory for small animals, in that it is difficult to keep them clean while in such. The nearer the stall fits the animal the easier it will be to keep it clean. So plan the stall well; it may be in use fifty years.

SPACE PER ANIMAL—SIZES FOR SMALL AND LARGE CATTLE—SPACE PER ANIMAL

	Length from manger to gutter	Width of stall	Breeds
For large cattle..................	5′ 2″ to 5′ 8″	3′ 6″ to 4′	Holstein. Shorthorn.
For medium cattle...............	4′ 6″ to 5′ 2″	3′ 6″ to 3′ 10″	Ayrshire. Gurnsey.
For small cattle..................	4′ 4″ to 4′ 8″	3′ 3″ to 3′ 6″	Jersey.
Young cattle......................	3′ 8″ to 4′ 2″	3′ to 3′ 2″	Any breed according to age.

MANGERS

The manger is the dinner plate and it is here that what you give the animal either makes or breaks you. A manger that permits waste over a series of years may cost you more than the stable. So plan it right. See that it is big enough, easy to clean, easy to get the feed into and easy for the animal to feed out of.

THE BARN FRAME

There is a wide gap between the old type of timber frame barn, that had crossbeams every twelve or fourteen feet, and the modern truss or braced rafter structures. Old frames, if sound, can even now in this modern day give good service. But to build a new all-timber frame to-day one needs to possess a woodlot or be quite close to a supply of good soft-wood timber. The chief objections to a timber frame may be stated as follows: Requires twenty per cent. more wood than does a truss frame; requires more help to raise a timber frame and the crossbeams may be in the way. The twenty per cent. saving in lumber is an item that cannot be ignored in most sections where all has to be purchased.

THE PLANK TRUSS OR SHAWVER FRAME

This frame is well braced and very strong. The truss is rigid and can be raised to position in good shape with the aid of a gin pole. The purline brace takes some wall space but this does not interfere with the settling of the hay or sheaves. For barns over 36 feet wide, this type of frame is advised. Its limitation in height is the length of planking available. At present it is not an easy matter to get plank over 30 feet long and quite a number of this length are needed if the space between the ridge and floor exceeds 30 feet. The difficulty in getting long planking may limit the width of many prospective barns to 36 feet or less. A barn only 36 feet wide can be built with planking not over 16 feet long if the braced-rafter type of structure is acceptable. It is amply strong for this width. The plank truss type of structure calls for the building of the basement or stable section to the completion of the floor for the superstructure, in order that the trusses may be made and raised into position where built. As the truss is built up it goes into position; they are set 12 to 16 feet apart and tied firmly with girts placed four feet apart. When all the trusses are up, the plates are raised and spiked into position. Then the purlines of double 2″ x 10″, with blocking between, are raised with block and tackle and placed to support the rafters. The siding should next go on, being nailed directly to the girts, up and down. The rafters are then placed and spiked, the lower to plate and purline, and the upper to purline and ridge. See figure 1 for truss construction for barn 36 feet wide or over.

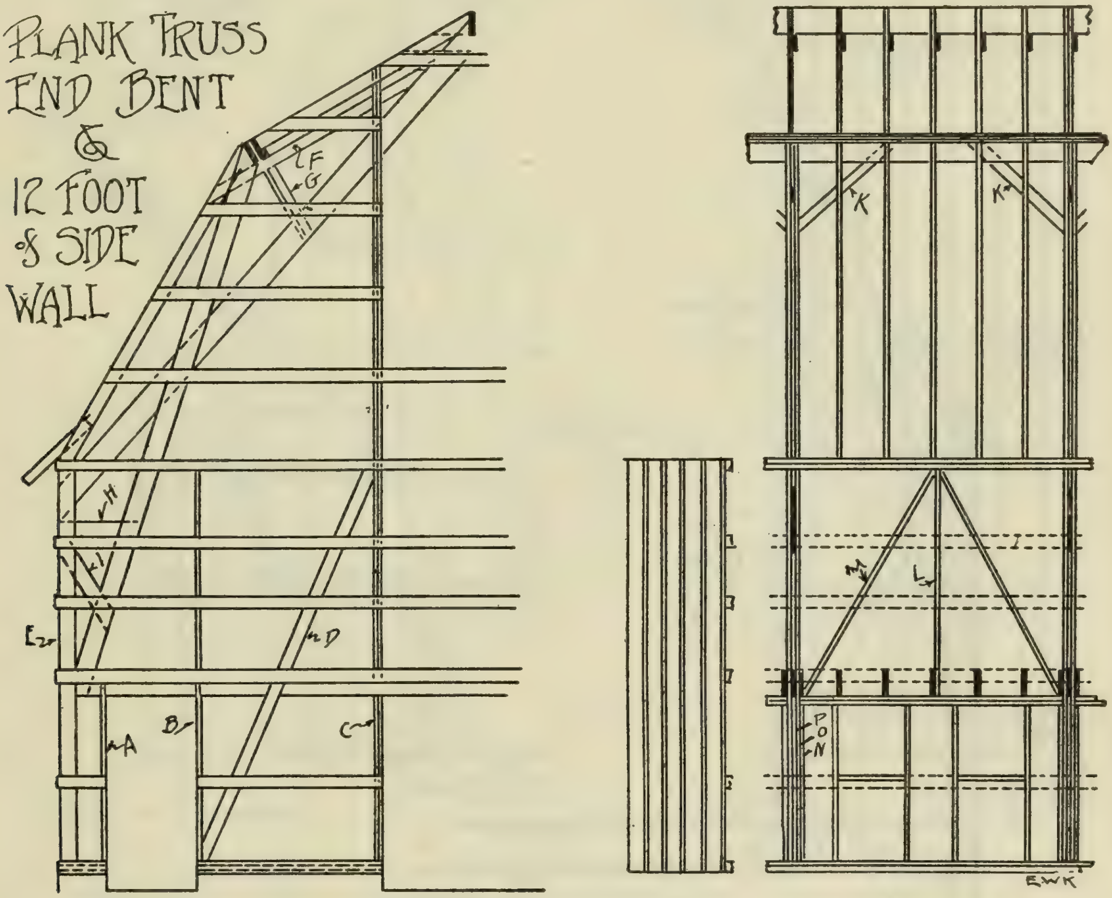


Fig. 5.

The Braced Rafter Frame

The trusses are lighter and easy to raise into position. It is amply strong for small or medium-sized barns, up to 36 feet in width, and not having a wall more than 18 feet high. In barns of this type of structure, the walls are framed of 2″ x 6″ studding set 24″ apart and cut to reach from sill to plate. Each stud is notched at a height to give an eight-foot six-inch space clear of the stable floor. This notch receives the 2″ x 6″ ribbon on which the upper floor joists rest at the wall ends. The ribbon is spiked to the stud and the joist is also spiked to the stud. See drawing 6 for this structure. The siding is nailed directly to the studding, binding the structure firmly together. All siding is nailed in place and the upper floor laid on the joists before the rafters are made. This gives a

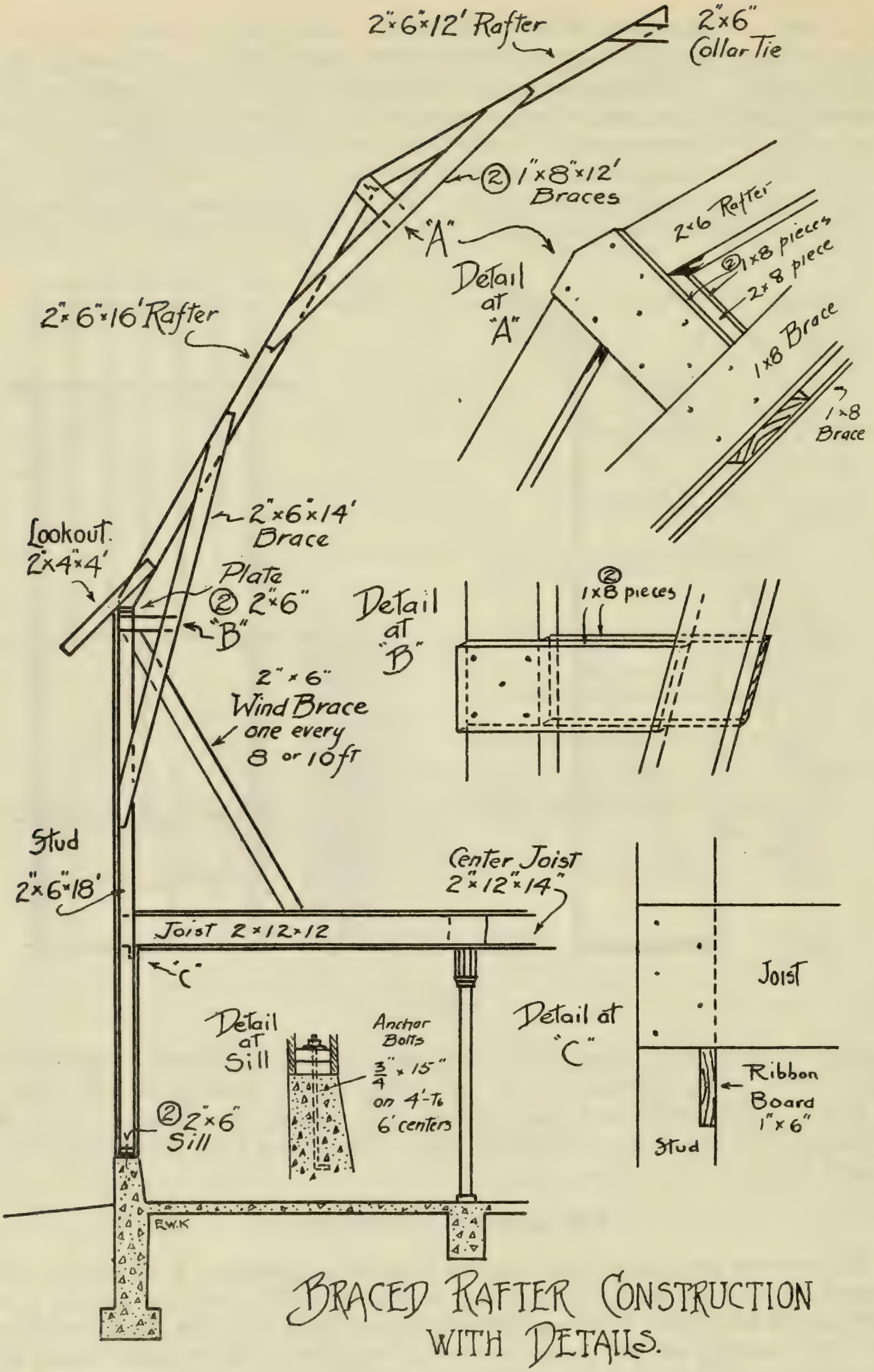


Fig. 6

level place on which to cut and shape the braced rafter. As the rafters are made they are elevated by aid of the jin pole, block and tackle, or push poles if enough men are handy by. Rafters are made of 2″ x 6″, cut and shaped as shown in figure 6. The rafter ties are preferably made of 1″ x 8″. The wall ties the same.

The rafters are set 24″ apart and spiked to the plate. The end frame next goes in and then the roof sheathing. The ends should be sheathed up before the roof is covered. The greater portion of the braced rafter type of frame is made of 2″ x 6″ in 12, 16, and 18-foot lengths. The floor joists are 2″ x 10″ in 12 and 24-foot lengths.

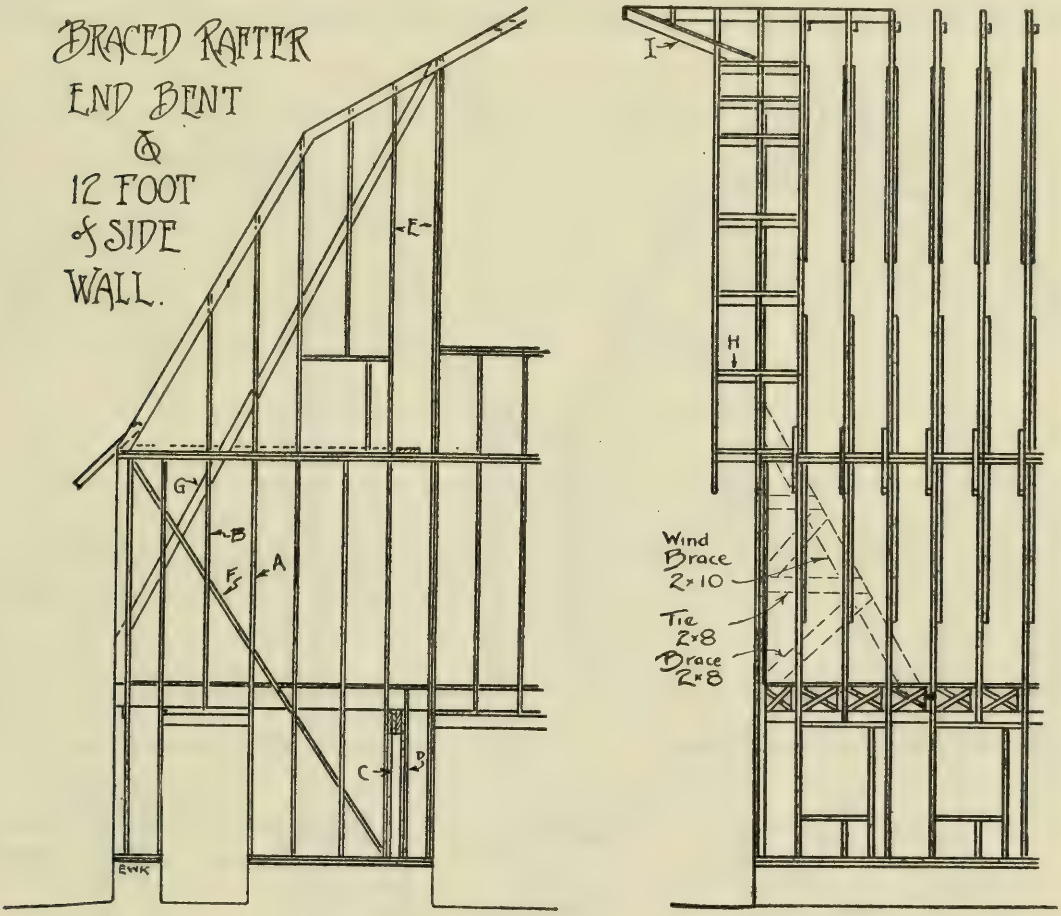


Fig. 7.

ALLEYS IN THE STABLE

In a stable 36 feet wide there is room to allow good width for both litter and feed alleys. Big cows will require more stall length, a larger gutter and manger, which may crowd the space allotted to alleys. Small cattle as Jerseys can and are better housed in a stable built to suit their size. It may be less than 36 feet wide for the two rows of stalls. With cattle "facing in," the feed alley may be six feet wide and the litter alley as wide as five feet, leaving 20 feet for walls, stalls, gutters and mangers. With cattle "facing out," the two feed alleys may each be four feet wide and the litter alley eight feet wide, leaving twenty feet for the other factors that complete the stable width. In northern sections, where long periods of zero weather may be experienced, a stable as narrow as thirty-two feet, to accommodate two rows of cattle, would be best. In such a narrow stable the space allotment could be: Stalls, 5′ 4″; mangers, 21″; gutters, 16″; feed alley, 3′ 10″; litter alley, 6′; wall, 9″. The intense winter cold is a factor that may be neglected in planning stables for the north country, as ventilation largely depends on the heat generated by the animals that occupy the stable. Excess humidity must be eliminated from the stable or it will congeal on the walls and floors. Excess moisture is very injurious to the well-being of stabled cattle, sheep, swine or horses.

The time to arrange the ventilation in the new stable is when the plan is being drawn. Correct ventilation does not just happen. The barn and its ventilating system must be built according to a simple principle of applied physics. Doorways, holes in the wall, windows and carelessness will not keep the stable air in the best condition for livestock. The successful ventilating system will remove excess moisture, poison gases, odours, and at the same time keep the air in reasonably good condition for both the animals and those working with them. During the cold winter period, the cow's body can heat about 600 cubic feet of well-insulated stable space; smaller animals, proportionally less. It is the body heat passed off by the animal that should keep her body comfortable and supply the necessary circulation to give her fresh air to breathe. If the space is too large, the animal cannot generate enough heat to warm the air sufficiently to cause it to move up the ventilator shaft with its load of moisture. Under such structural conditions we get a cold, moist, gas-saturated and foul-smelling air, with more or less ice on the walls, windows and floors. Stables that have been built with too much air space per animal can be ventilated in one way during the excessive cold periods, and that way is to put in artificial

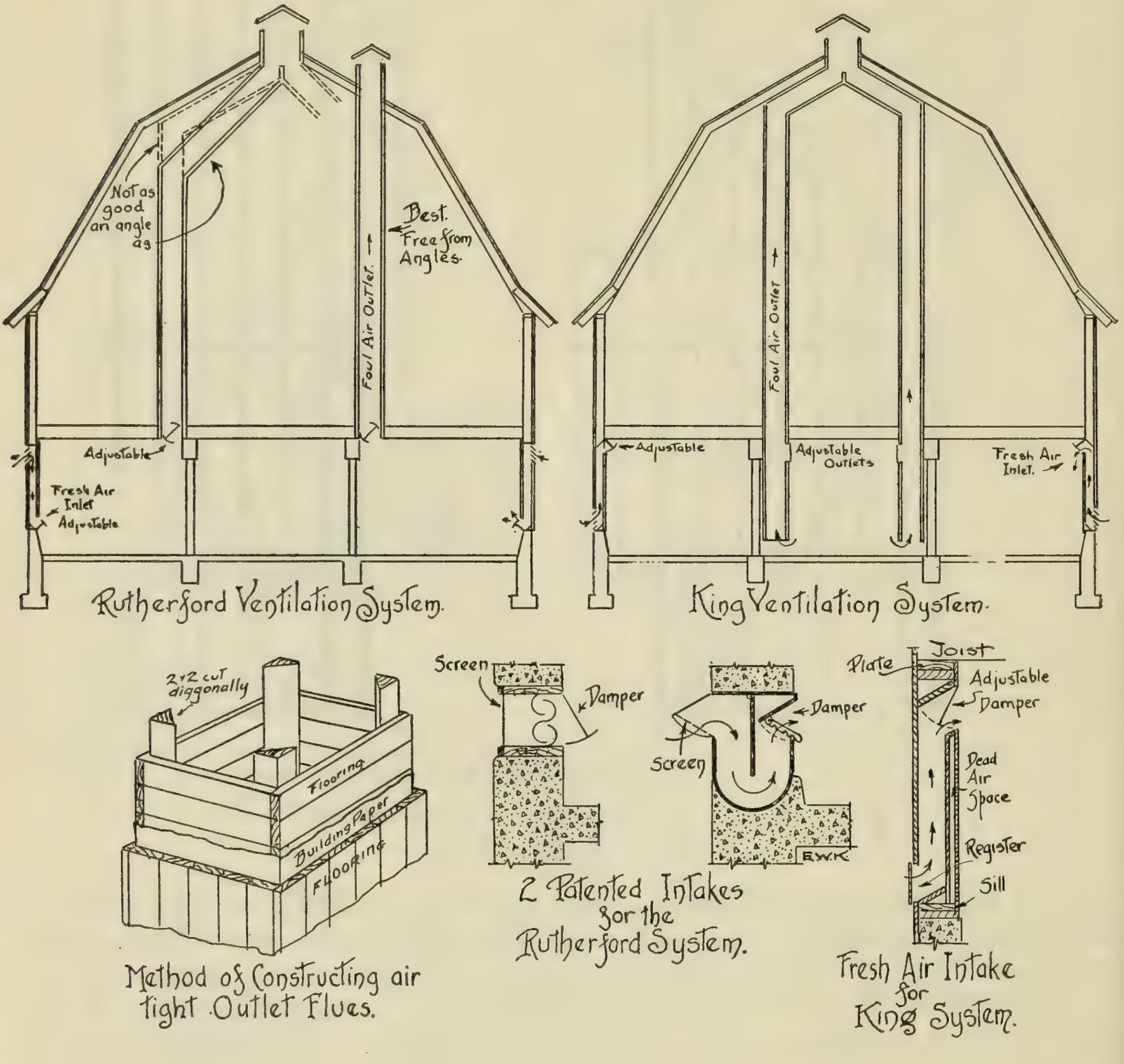


Fig. 8.

heat to help the animals keep the temperature up to a point that will bring about the working of the ventilating system. Plan the stable to give each animal sufficient space for comfort (not over 600 cubic feet for mature cattle and 750 cubic feet for a horse; smaller animals in proportion). More space is a disadvantage during the winter period when stock are using the stable most.

GOOD STRUCTURE NECESSARY FOR EFFICIENT VENTILATION

Poorly fitted doors and windows, cracks in the walls, stone or concrete without insulation are factors that defeat the efficient working of any ventilating system. Heat is the force that works the system, so if heat is lost through poor doors, windows or walls there may not be enough heat left in the stable to force the moisture-laden, foul air up and out the flue. Windows, doors and cracks will, of course, let in fresh air, but such a method requires too much attention to be a profitable way of ventilating; the air may be very fresh at times or very foul too frequently.

WOOD WALLS THE BEST

A concrete foundation stub wall that rises eighteen inches above the stable floor is a good type of foundation on which to build a wood wall that can be easily fitted with inlets for air. The wood wall does not waste heat. It is warm, easily insulated and not difficult to construct. Stone and concrete basement walls should be insulated with a wood covering. Double sash for all windows and double doors are heat-savers and therefore add to the efficient working of the ventilating system in cold sections.

During the summer when the temperature outdoors is about the same as the stable temperature, the ventilating system will not work, hence doors and windows must be opened or a forced draft created if the stable is to be used during the warm period.

FRESH-AIR INTAKES

If a reasonable standard of air purity is to be maintained in the stable, provision to admit 3,500 cubic feet of air per hour for each cow must be arranged. This can best be done by providing fresh-air intakes along the stable wall. These intakes may be as close as eight feet or as far apart as fifteen feet, according to the width of the stable, location, height of ceiling, and etc. It is best to bring the air in at the ceiling, thereby preventing draft on the animal and causing the cold air to mix with the warm before it reaches the animal's nostrils. In wooden-walled buildings as described in the preceding paragraph, the inlets are constructed between the studs, the inner or discharge opening being at the same height as the ceiling and the outside or intake opening not less than four feet lower. Inlet flues should be made of tongued and grooved lumber and fitted tight. An air space should be left between the flue and the inside sheeting of the stable wall. In stone or cement walls, flues made of galvanized metal or tile can be built in when the wall is being constructed.

OUTLETS FOR FOUL AIR

The outlets for foul air should be in the ceiling, preferably behind the animals. With cattle facing out, the outlets would be near the centre of the building, while with the facing-in arrangement, the outlets would be at the sides. The outlet must be well constructed of double lumber, tongued and grooved, with heavy paper between, practically air-tight in so far as any leakage through the sides is concerned. Poorly constructed outlets are no better than a hole in the ceiling. The outlet should have a smooth inside surface, should be free from sharp bends and connect up the ceiling and ventilator cupola tightly to prevent any interference with the air that it is designed to carry from the stable.

SIZE OF INLETS AND OUTLETS

For Ontario conditions, where a system that is part King and part Rutherford proves most satisfactory, the outlet opening and the inlet opening should be figured on the basis of 25 square inches per cow and 30 square inches per horse. Other animals in proportion. On this basis a stable sheltering 30 cows would require a total of 900 square inches of inlets and an equal amount for outlets. A thirty-cow stable would have twelve inlets (six on each side), each 4″ x 20″. This size will fit between the studding set two feet apart. Two outlets, each having an area 25″ x 18″, for a stable where the animals face out, or four outlets, each having an area of 14″ x 18″, would remove the foul air from a stable of this size (thirty-cow). The outlet exit should be placed flush with the ceiling and equipped with a control damper for use in very cold or windy weather. The cupola into which the flue is to discharge its load of foul air is a very important unit in the ventilation of a stable. It should be large enough that no resistance will be placed on the up-flowing air from the stable. It should be high enough that the influence of wind may be utilized. It should be open enough to offer no barrier to the wind, which, if permitted to blow freely through the cupola, will aid by creating a suction that will move the heavier air from the stable that we are trying to ventilate. The figures given for size of inlet and outlet are for buildings thirty feet at the ridge. Buildings over thirty feet high can have correspondingly smaller inlets and outlets.

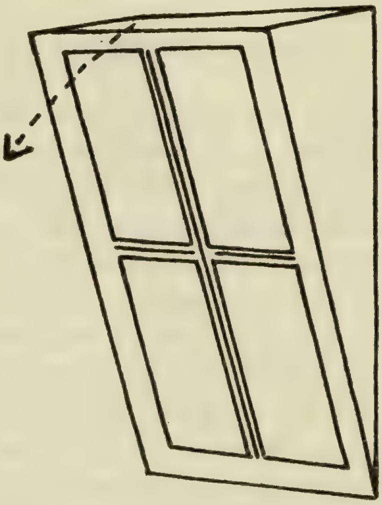


Fig. 9—"Sheringham Valve" Window hinged at bottom and made to close between the side pieces. Top of sash opens inward to admit air.

MAKESHIFTS

When a complete ventilating system is not desired because of cost, aids to ventilation may be substituted.

Such will give some service in supplying fresh air to the animals and removing stable odours if sufficient attention is given to them. The "Sheringham Valve" (see figure 9) makes a satisfactory inlet. It is arranged by hinging the window at the bottom so it may drop inwards at the top and rest between triangular sidepieces. The air is deflected upward at the point of entrance, striking the ceiling and then diffusing through the stable to an outlet such as described in the preceding paragraph. This window inlet takes a lot of attention. The practice of using a hay chute as a ventilator is not very satisfactory and at best can only be a makeshift as too much air is drawn from one centre during periods of low temperature. The use of muslin in place of glass will admit fresh air without serious draft and if the stable is equipped with foul-air outlets, fairly satisfactory results are obtained, providing the muslin is kept in good condition.

REMODELLING THE OLD BARN

The inclination to "make the old barn do for a while yet" is noticeable in many districts. This is quite in keeping with the small profits on farm operations and the high cost of new structures. With building material and labour at their present level, a modern barn costs half as much as a good farm. So we can readily understand the desirability of making the barns that were put up fifty years ago continue in service.

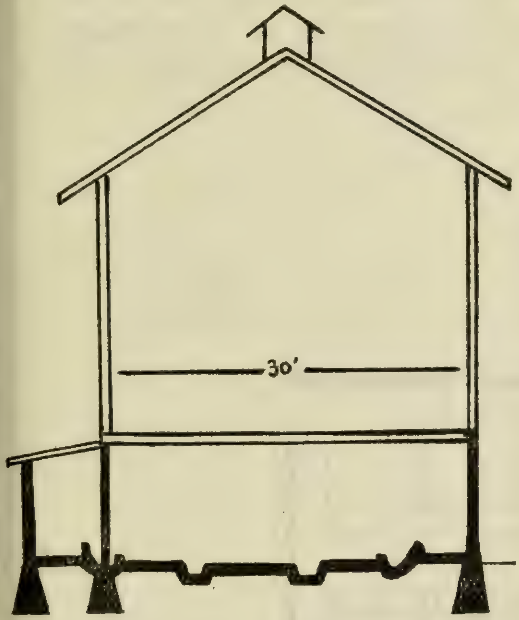


Fig. 10—A lean-to six feet wide built on side of old barn, to make the necessary 36 feet for modern stable plan. Row of posts set 10½ feet apart in manger line, at stall divisions supports the superstructure.

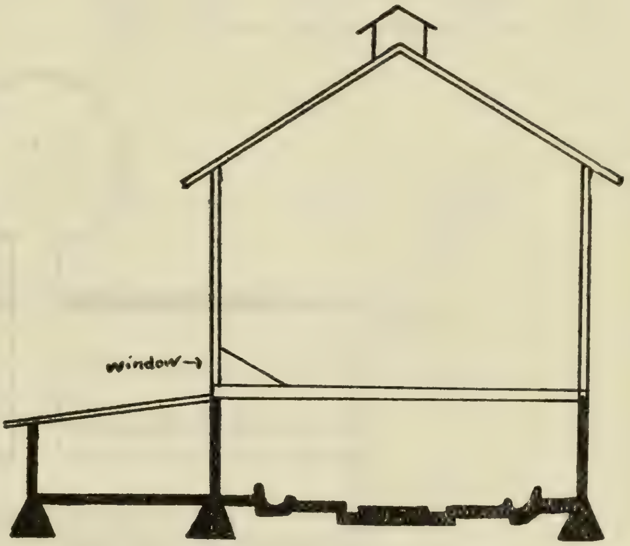


Fig. 11—A lean-to built on side of old barn, to make accommodation for young stock, when it is not desired to lengthen the barn, which in this case was wide enough to suit a modern stable lay-out.

Many of the old structures have good timber frames. The roof may be leaky but the sheathing good; the foundation, usually the weak point in barns built years ago, probably gone. It is surprising what labour and repair material, intelligently applied, will do towards making over one of these old structures, and providing a barn which, while not modern in every way, will give a high degree of efficiency. An old barn, built 32 to 36 feet wide, can be arranged on the same plan as the most modern barn. But the common fault of old barns is that they are built too narrow and will not permit the use of the two-row standardized form of stable plan.

Narrow old barns can, of course, be widened to give the needed four or eight feet required, by building a lean-to on one side to accommodate in part one row of stalls, and this is done frequently. See figure 10, showing how a barn thirty feet wide was made to suit a modern plan. See figure 11, old barn planned to give room for young stock, where it was not desired to lengthen the barn.

WIDENING A NARROW BARN

The siding on one side wall of the old stable is removed and its foundation reconstructed to suit. Large stone pillars or blocks of cement concrete are placed in line and spaced to suit the posts, that are set every 10½ feet, to support the superstructure. A stub wall is then built parallel to the old wall and at a distance to give the desired width of stable. On this new stub wall, the wall of the lean-to is built. Studs are set two feet apart, double-boarded on the outside and preferably boarded on the inside. The roof is given just sufficient pitch to give good run-off (one foot in six). Windows and fresh-air intakes are built in the same as for all modern structures. With the wall up, the stable grade can be arranged and the cement concrete floor, with mangers and gutters, laid according to a modern plan. Some attention should be given to providing abundant light, sometimes difficult in old buildings, but is of sufficient importance to warrant the expenditure of both time and money. New siding, battens and shingles may be needed. If so, put them on, and don't forget to stain or paint, that the surface may be saved. Stain is the best for barns. Put it on with a spray pump, such saves time and labour.

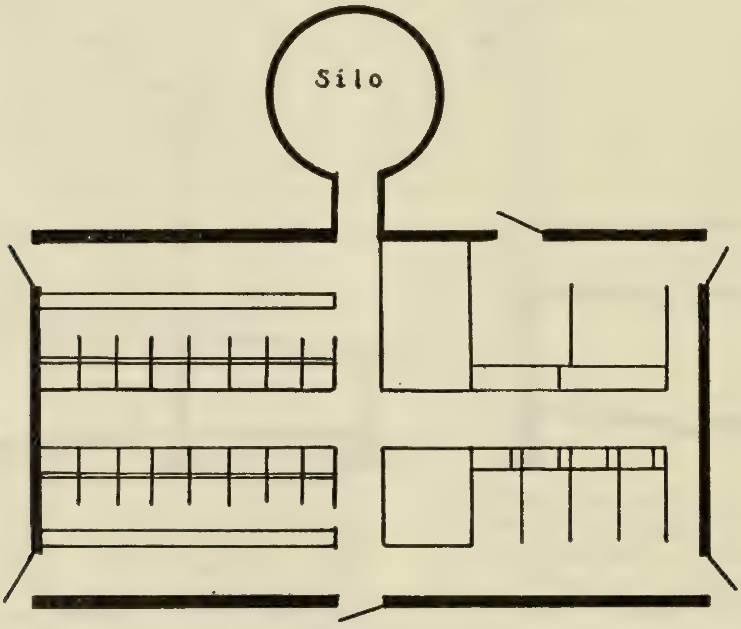


Fig. 12—Lay-out for barn 36′ x 64′. 16 cattle stalls, 4 horse stalls and 4 box stalls.

TO LAY OUT THE FOUNDATION LINES FOR A SMALL BUILDING

1. Determine the position of one of the corners (front). Drive in a stake, "A." Drive a nail into the top of this stake from which to take accurate measurements.
2. Measure from this stake, mark and drive in another stake, "B," where you wish the other front corner to be. Put in a nail, as with "A," at the exact distance or length of the building measured from the nail in "A."
3. Drive in a third stake, "C," at 6 feet from "A." Put in the nail at the exact distance from the nail in "A," and in line with nails "A" and "C."
4. Measure 8 feet directly back of "A" and 10 feet from "C" to get a point "D." Drive in a stake and then a nail at the exact distance. This will give you a square corner. The last step may be done in several ways. (*a*) Procure two long tape lines, hook the rings at the ends of the tapes over the nails in "A" and "C," carry them back and where they cross,

with 8 feet on the one and 10 feet on the other, is the point. (*b*) Take two sticks, one 8 feet and the other 10 feet long, and use them to measure with instead of the tapes.

5. On a line passing back from the nail "A" through the nail "D," locate the back corner "E." Drive in a stake and a nail.

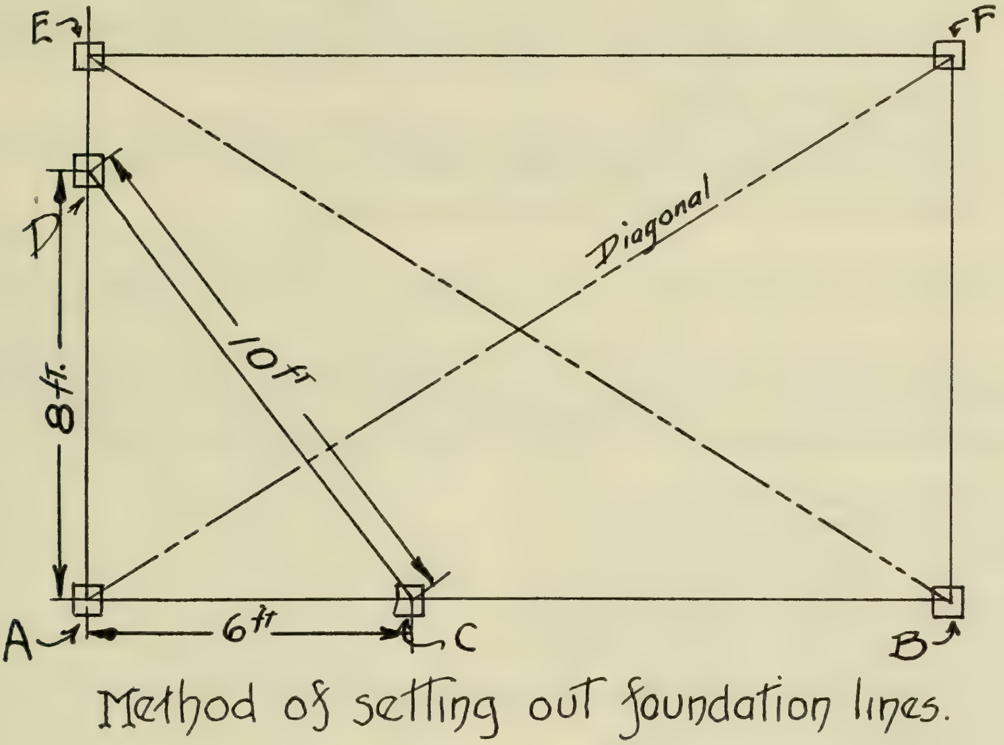


Fig. 13.

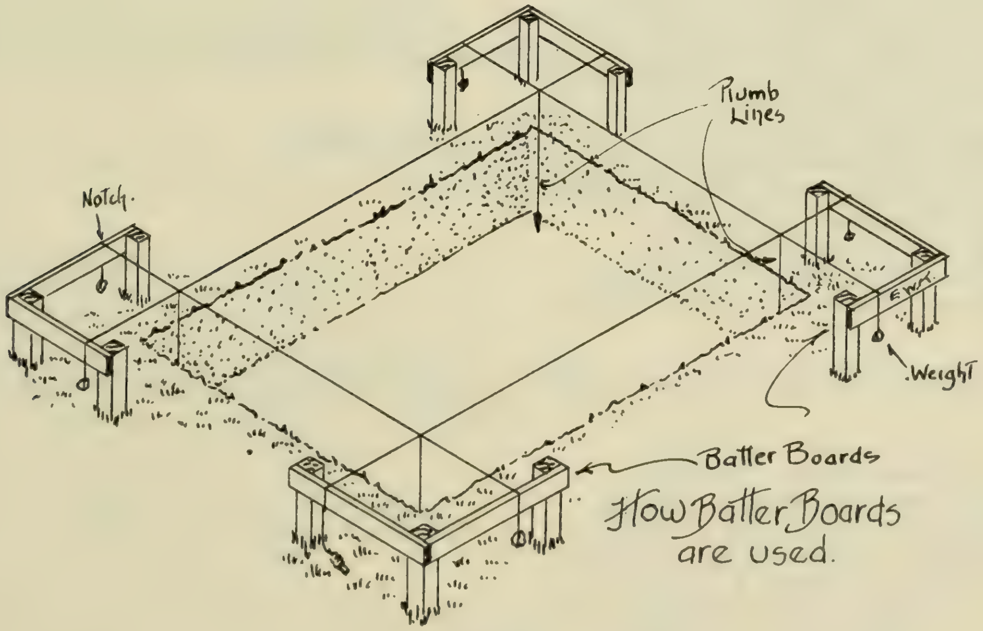


Fig. 14.

6. Locate the other back corner as in 4 and 5, or measure the distance from "E" and "B" with tapes. Drive in a stake and mark on the stake where the nail is to go. Measure from this mark to the nail in "A." Then measure from the nail "E" to the nail "B." If both are the same the

point is correct and you may drive in the nail. If they are not alike, move the point until they are.

7. As the stakes would fall in when you excavate and it is necessary to have exact points to measure from, proceed as follows. About 6 feet from the corners in both directions away from the foundation, erect a sort of fence as shown in figure 14. These are called batter boards.
8. When all are in position, stretch four cords over these boards and exactly over the nail heads in the stakes. Put weights on the ends of the cords to stretch them tightly.
9. Make a little saw-cut where the cords rest on the batter boards and the cords may be replaced any time. Stakes may now be removed. Replace lines from time to time to check measurements.

ESTIMATE OF MATERIALS REQUIRED IN PLANK TRUSS FRAME BARN

For each 12 feet of length, of barn 36 feet wide and with 18-foot side walls, the following lumber is required. (If you are building a barn 60 feet long, multiply the quantities by 5; if 96 feet long, then multiply by 8.)

Sills—Four pieces, 2″x8″x12′.
Post, Part A—Four pieces, 2″x8″x7′.
Post, Part B—Four pieces, 2″x8″x18′.
Post, Part C—Two pieces, 2″x8″x8′.
Basment Studs—Eight pieces, 2″x6″x7′.
Basement Studs—Four pieces, 2″x6″x3′.
Basement Plate—Four pieces, 2″x8″x12′.
Brace D—Four pieces, 2″x8″x12′.
Stud E—Two pieces, 2″x8″x10′.
Lower Rafters—Twelve, 2″x6″x16′.
Upper Rafters—Twelve, 2″x6″x12′.
Purlin Braces K—Four pieces, 2″x6″x7′.
Strut G—Four pieces, 2″x6″x4′.
Brace F—Two pieces, 2″x6″x12′.
Collar Ties—Six pieces, 2″x10″x6′.
Ridge Board—One piece, 2″x10″x12′.
Roof Sheathing Boards—Ninety-three pieces of 1″x6″x12′, to lay 2″ apart.
Shingles—7 squares require 28 bundles.
Mow Floor—518 feet of D. and M. flooring.
Basement side walls—200 feet of 1″x6″ D. and M. flooring.
Siding—Thirty-two pieces, 1″x10″x18′.
Battens—Thirty-two pieces, 1″x3″x18′.
Joists—Fourteen pieces, 2″x10″x12′.
Joists—Six pieces, 2″x12″x14′.
Girders—Eight pieces, 2″x12″x12′.
Bridging—Thirty-six pieces, 2″x4″x2′.

MATERIAL FOR END FRAMING SAME BARN, ONE END ONLY, IN THIS ESTIMATE

Sills—Four pieces, 2″x8″x10′.
Plates—Four pieces, 2″x8″x18′.
Studding A—Two pieces, 2″x8″x8′.
Studding B—Two pieces, 2″x8″x18′.
Studding C—Eight pieces, 2″x8″x18′.
Brace D—Two pieces, 2″x6″x20′.
Post E—Four pieces, 2″x8″x18′.
Post E—Four pieces, 2″x8″x7′.
Post E—Two pieces, 2″x8″x7′ 4″.
Purlin Post—Two pieces, 2″x10″x26′.
Ridge Post—Two pieces, 2″x12″x28′.
Lower Rafter—Two pieces, 2″x6″x16′.
Upper Rafter—Two pieces, 2″x6″x12′.
Collar Tie—One piece, 2″x10″x6′.
Brace F—Two pieces, 2″x4″x12′.
Strut G—Two pieces, 2″x4″x4′.

Lookout—Two pieces, 2″x4″x4′.
Tie H—Two pieces, 2″x8″x4′.
Brace I—Two pieces, 2″x8″x5′.
Nailing Girts—250 linear feet of 2″x6″.
Siding—1,200 board feet, 1″x10″x18′.
Battens—600 linear feet of 1″x3″.
Frieze Board—56 linear feet of 1″x12″.
Corner Trim—Four pieces, 1″x4″x18′.
Door Casing—Five pieces, 1″x4″x8′.
Basement End Wall and Doors—325 board feet of 1″x6″ D. and M. flooring.

MATERIAL FOR END BENT OF BRACED RAFTER TYPE BARN FRAME, THIRTY-SIX FEET WIDE

Sills—Four pieces of 2″x8″x10′.
Plates—Four pieces of 2″x10″x18′.
Studding A—Sixteen pieces of 2″x6″x18′.
Studding B—Five pieces of 2″x6″x12′.
Studding C—Four pieces of 2″x6″x6′.
Studding D—Two pieces of 2″x6″x8′.
Studding E—Six pieces of 2″x6″x18′.
Miscellaneous Studding—2″x6″. 66 running feet.
Brace F—Two pieces of 2″x6″x20′.
Brace G—One piece of 2″x6″x30′.
Door Lintel—Two pieces, 2″x8″x8′.
Door Lintel—Four pieces, 2″x6″x4′.
Lower Rafter—Two pieces of 2″x6″x16′.
Upper Rafter—Two pieces of 2″x6″x12′.
Lookouts—Two pieces of 2″x4″x4′.
Collar Tie—One piece of 2″x6″x6′.
Ridge Board—One piece of 2″x12″x12′.
End Lookout Support H—Fourteen pieces of 2″x6″x4′.
Ridge Brace I—Two pieces of 2″x6″x7′.
Drop Siding—1,400 board feet.
Wall in Basement—300 feet matched flooring.
Frieze Board—1″x12″, 72 running feet.
Corner Trim—1″x4″, 72 running feet.
Door Casing—1″x4″, 60 running feet.
Concrete for End Wall—216 cubic feet.
Wind Brace—Two pieces of 2″x10″x14′.
Wind brace—Three pieces of 2″x8″x12′.

MATERIAL FOR A TWELVE-FOOT SECTION OF BRACED RAFTER TYPE BARN FRAME, THIRTY-SIX FEET WIDE

Sills—Four pieces of 2″x6″x12′.
Plates—Four pieces of 2″x6″x12′.
Lookouts—Twelve pieces of 2″x4″x4′.
Studding—Fourteen pieces of 2″x6″x18′.
Braces J—Twelve pieces of 2″x6″x14′.
Braces K—Twenty-four pieces of 1″x8″x12′.
Braces Ties—Forty-eight pieces of 1″x8″x1½′.
Collar Ties—Six pieces of 2″x6″x6′.
Girders—Eight pieces of 2″x12″x12′.
Joists—Eighteen pieces of 2″x12″x12′.
Bridging—Thirty-six pieces of 2″x4″x2′.
Drop Siding—540 board feet.
Shingles—30 bundles.
Mow Floor—518 board feet of 1″x6″ D amd M flooring.
Wall Surface—200 board feet of 1″x6″ D and M flooring.
Ceiling—540 feet of five-eighths by four-inch beaded ceiling.
Frieze Board—Two pieces of 1″x12″x12′.
Window Frames—Four 9 lights, 9″x12″ glass.
Sash—Four 9 lights, 9″x12″ glass.
Anchor Bolts—Four (¾″x15″).
Columns—Two 4″x8′, cast iron with top and base plates.
Concrete for Floor—136 cubic feet.
Concrete for Foundations—144 cubic feet.

Estimating the Material for a Farm Shop

Foundations.—Concrete foundation usually calls for a 1:2½:5 mix. This means for every part of cement by bulk, you require 2½ parts of sand and 5 parts of gravel. In concrete work, by sand, we mean all pieces that will pass a quarter-inch mesh screen. If you use bank-run of gravel without screening it, there is a danger of getting too large a portion of sand for good concrete. It pays to screen. To make a cubic yard of concrete with the 1:2½:5 mix, you require 5 bags of cement, 12½ cubic feet of sand, and 25 cubic feet of gravel.

Floors.—The strongest mix for concrete floor is the 1:2:4. This requires for each cubic yard, 6 bags of cement, 12 cubic feet of sand and 24 cubic feet of gravel.

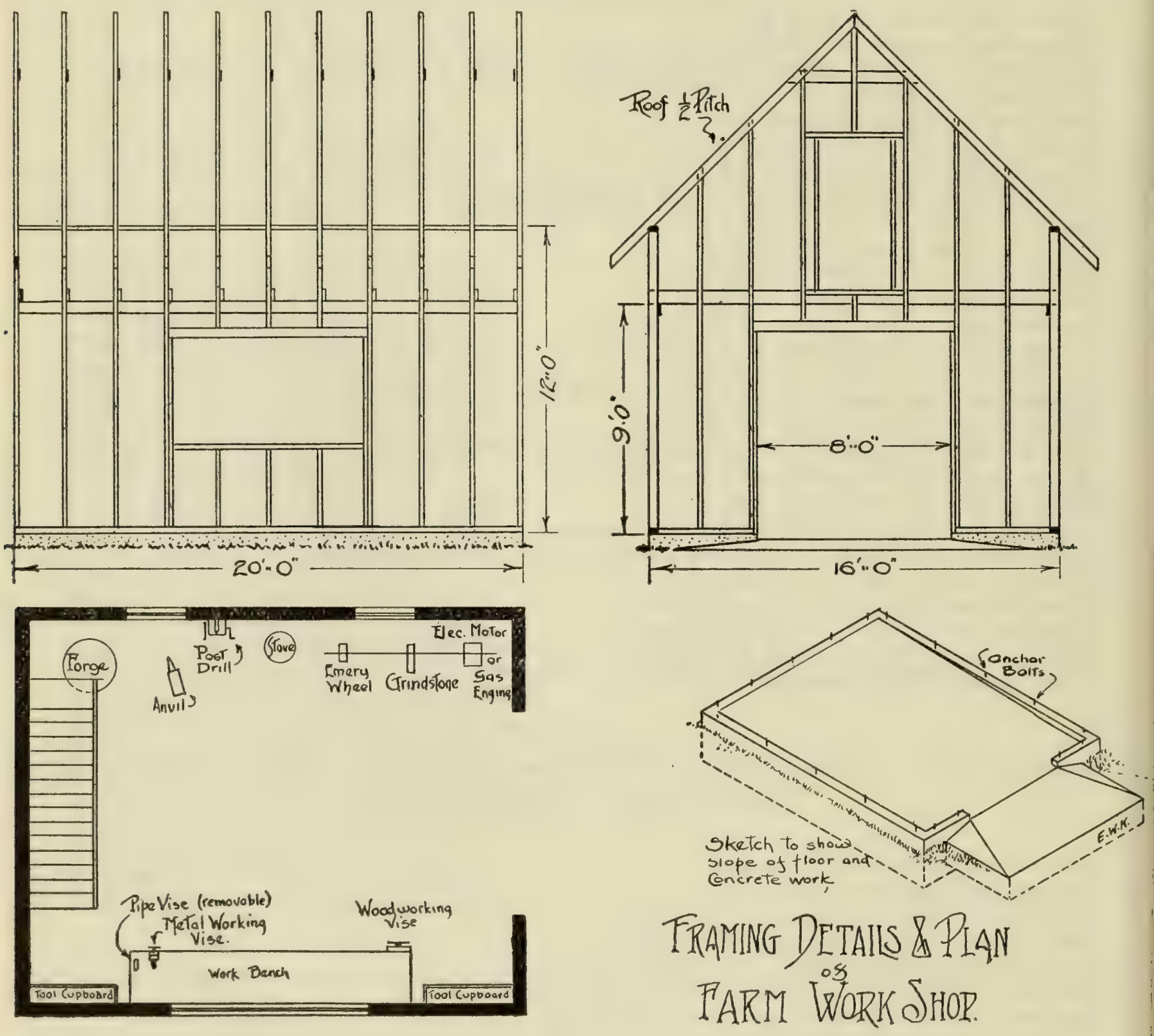


Fig. 15.

Anchor Bolts.—Bolts one-half inch in diamater and 15 inches long are very satisfactory if placed about four feet apart on the sides and ends. See that a bolt is placed at the end of each line, eight inches from the corner.

Sills.—Sills of two inch by four inch do very well for small buildings.

Studding.—Studs of two inch by four inch, set two feet from centre to centr for walls. Allow double for corners, doorways and windows.

Plates.—A two inch by four inch makes a very satisfactory plate.

Siding.—If drop siding is to be used, calculate the area to be covered, deduc the area of the openings and add a fifth more to allow for matching. If vertica siding is to be used, calculate the area and deduct area of openings and add a twelfth if you use twelve-inch lumber, a tenth for ten-inch, and an eight if eight-inch lumber is used.

Rafters.—For a building 16 feet wide at the gable end, get two inch by four inch, cut 12 feet long for a third pitch roof, or 16 feet long for a half-pitch roof. The half-pitch roof is desirable if you want an attic.

Sheathing.—Roof sheathing is calculated the same as vertical siding.

Shingles.—A square of roof contains 100 square feet and requires four bunches of shingles to cover it, if the exposure is 4½ inches to the weather.

Cornices and Mouldings.—These are measured by the running foot. Allow an increase of 10 per cent. to cover waste in cutting.

Building the Foundation and Floor for a Farm Workshop

If foundations about three feet deep are to be built, in a soil that stands up well, it may not be necessary to build forms. Keep out loose earth by hanging a piece of burlap or building paper over the edge of the trench, on the side away from where you are filling. For the part above ground, plank forms six inches high will do. Put in anchor bolts (½″ x 15″) to bolt the sills to the foundation, before the cement sets. These bolts should be about four feet apart, starting about eight inches from the corners, and avoiding the place where the stud will stand. Keep the foundation lower at the door to allow for the slope of the floor, about three-sixteenths inch to the foot, from front to back. When the foundation has set hard, level up the ground inside, and prepare for the floor-laying. If the soil holds water in the spring, take out to the depth of fourteen inches, to allow for a well-tamped bed of cinders or stone and the four-inch coating of cement concrete. To build the floor, start at the back and put boards on edge, right across the area every three feet. The top edge of these boards should be very carefully placed at the floor level, allowing for the slope. Fill in behind the first board with concrete and level off with a wooden trowel; pack firmly. Remove the board and fill the next space, and so on out to the front of the building.

Material for a Farm Workshop, Sixteen Feet by Twenty Feet. (See Figure 15.)

Foundation—8″ thick by 3′ deep, requires 25 bags cement, 62 cubic feet of sand and 124 cubic feet of gravel.
Floor—4″ thick, requires 24 bags of cement, 48 cubic feet of sand, and 96 cubic feet of gravel.
Sills—Two pieces of 2″x4″x20′.
    One piece of 2″x4″x16′.
    One piece of 2″x4″x8′.
Plate—Two pieces of 2″x4″x20′.
Studding—Twenty-three pieces of 2″x4″x12′.
    Four pieces of 2″x4″x14′.
    Twelve pieces of 2″x4″x16′.
    Two pieces of 2″x4″x18′.
    Two pieces of 2″x4″x20′.
Ribbon Board—Four pieces of 1″x6″x10′.
Joists—Eleven pieces of 2″x6″x16′.
Rafters—Twenty-two pieces of 2″x4″x14′.
Roof Sheathing—1″x8″ hemlock, S.I.S. 620 board feet.
Shingles—24 bundles.
Drop Siding—1,100 board feet.
Flooring—400 board feet, D and M spruce.
Stairs—Five pieces 2″x10″x12′.
Facia Board—1″x6″ S.4.S., 100 linear feet.
Frieze Board—1″x6″ S.4.S., 56 linear feet.
Corner Trim—1″x4″S.4.S., 100 linear feet.

Window Trim—1″x4″ S.4.S., 60 linear feet.
Doors—1″x3½″, V-joint, 90 board feet.
Window Frames and Sash.
Nails—14 pounds common 4″.
" 6 pounds common 3″.
" 50 pounds common 2½″.
" 20 pounds galvanized 1¼″.
Anchor Bolts—Eighteen (½″x15″) with washers (36).
T. Hinges, Heavy—Six 12″.
T. Hinges, Heavy—Three 6″.
Latches, Padlock, etc.
Paint.

How to Cut a Rafter

It is comparatively easy to cut a pattern rafter, if one will first learn the meaning of the terms involved and then follow the directions.

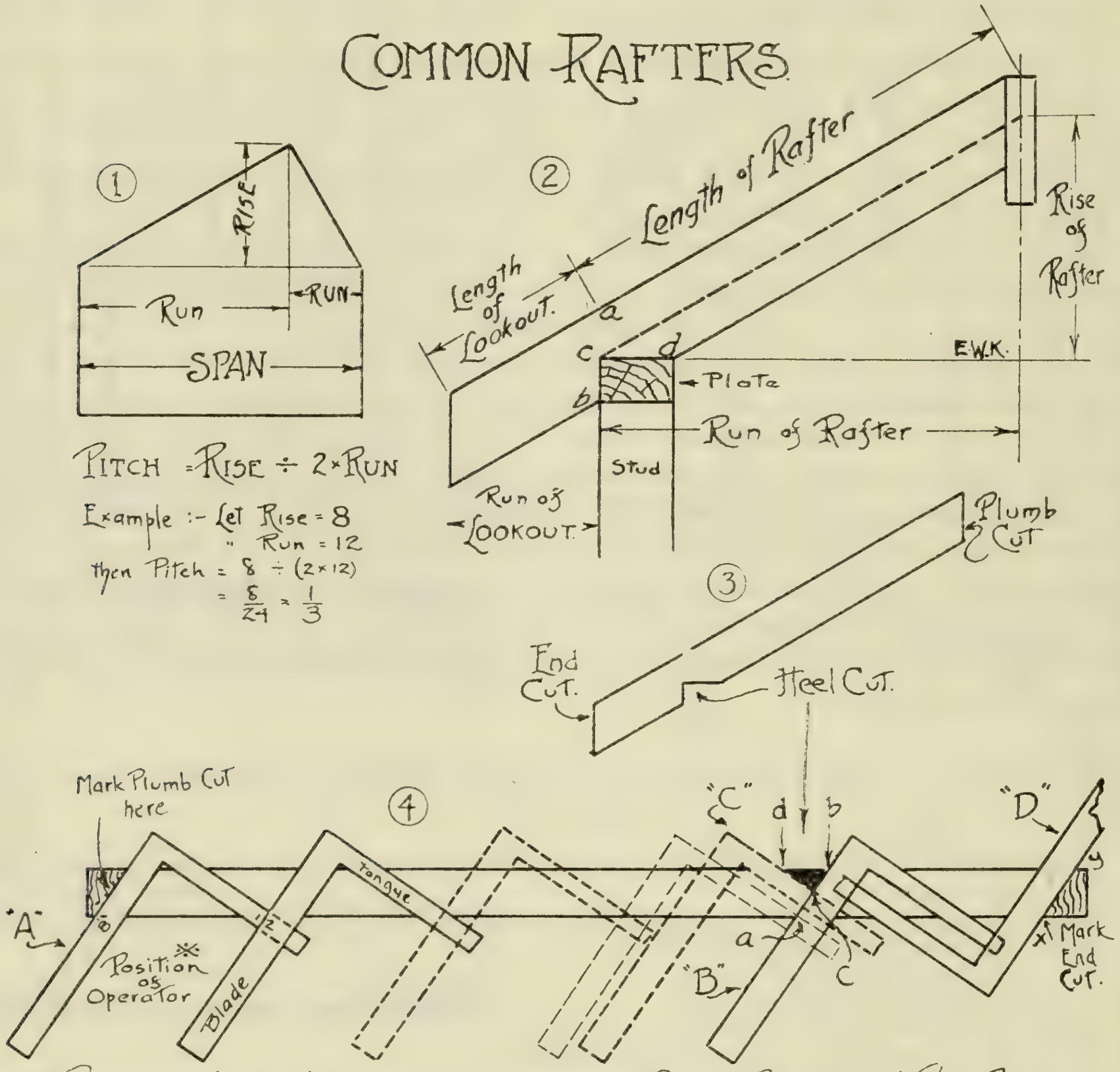


Diagram to illustrate method of setting out a Pattern Rafter for 1/3 Pitch Roof with Run of 4 feet and Overhang of 1′-5″.

Figures to use on Square for Common Rafters.

When Pitch is = ½ use 12″ on Tongue and 12″ on Blade.
" " " = ⅓ " 12″ " " " 8″ " "
" " " = ¼ " 12″ " " " 6″ " "

Fig. 16.

The pitch or slope is expressed as a fraction. "One half" pitch means, that if the rise is 12 inches the run is also 12 inches. See figure 16. In the "one third" pitch roof, there is a rise of eight inches for every foot of run. To mark the cuts for a "third pitch" roof, we use the figure 8″ on the blade and the figure 12″ on the tongue of the framing square.

Plumb Cut.—Stand with the top end of the rafter toward you. Hold the blade of the square in the left hand, with the mark 8″ on the blade and the 12″ mark on the tongue against the top of the rafter. Mark a line across the rafter against the blade. (See position "A" in figure 16, illustrating the cutting of rafters.)

Length of Rafter.—To obtain the length of the rafter, stand as before, holding the square with the same figures as for plumb cut against the edge of the rafter, and mark where the figure 12″ on the tongue touches the rafter. Now place the square with the figure 8″ against this mark and again mark where the figure 12″ comes. Do this for every foot of run of the rafter. In the drawing illustrating the cutting of rafters "A" in figure 16, it has been done four times, bringing the mark to the letter "a." Note that the term "length of rafter" is equivalent to length of "pitch line."

Heel Cut.—Having marked the length, hold the square as before with the blade crossing the mark at "a." Mark a line A B C across the rafter against the blade (position B4, see figure 16). Now move the square to the left until the tongue crosses this line at its centre and mark a line straight against the tongue (position C, see 4, c to d, figure 16). The angle formed "b c d" is the "Heel cut." It is shown blackened in the drawing.

Length of Lookout.—The end is sometimes cut off square, but a better appearance is obtained by keeping the same angle as the plumb cut. Keeping the 8″ and 12″ marks as before, move the square to the right, once for every foot of overhang, and mark off along the blade. If the length will not allow this, turn the square over, and reverse it as is shown in position D4, figure 16. This puts the blade to the right. Mark off along the blade.

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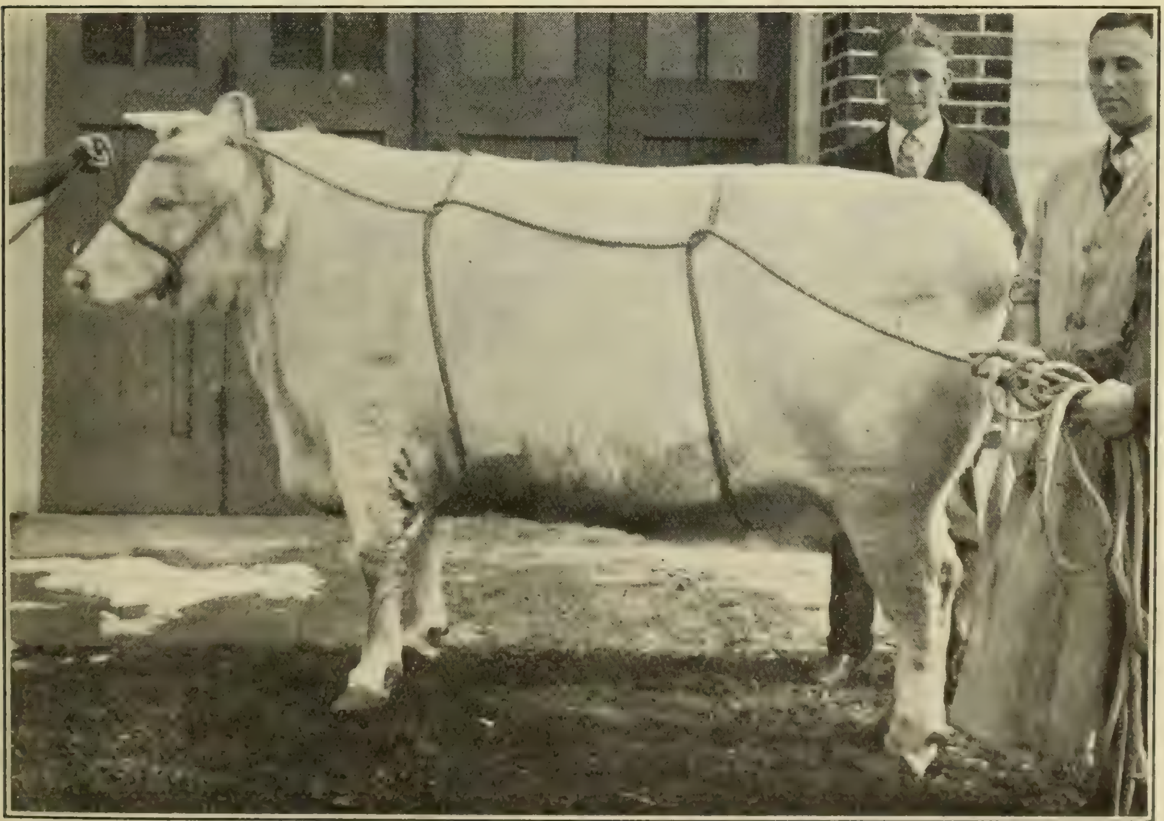
Ontario Department of Agriculture
ONTARIO AGRICULTURAL COLLEGE

KNOTS AND SPLICES

The Use of Rope on the Farm

E. W. KENDALL, B.S.A., Associate Professor in Agricultural Engineering
and
L. STEVENSON, B.S.A., M.S., B.V.Sc., Director of Extension



Rope as used in casting a cow.

THE USE OF ROPE ON THE FARM

On every Ontario farm, rope is used in some way every day of the year. The use may not be extensive, but the sum-total of rope service for a year on the well managed farm is an item of considerable importance. Rope costs money. Real hard earned cash is passed out each year for new rope. It may be required for hay tools, the grain slings, animal halters, tackle block hoists, load lashing, plough lines, clothes lines, lariats, well ropes, and many minor uses. The livestock man must have rope for the efficient handling of his animals while stabled or during transportation. When heavy objects must be elevated, rope forms part of the equipment. Much of the hay and grain crops are now handled by equipment that is largely rope.

Practical knowledge of the rope and its use will save many losses and greatly increase its period of usefulness. How to splice the broken hay fork rope and keep the work going with a minimum of delay is a knowledge that has a cash value to the farmer; to know how to tie a horse so that the knot will not slip and strangle the animal is also a good thing for both the horse and its owner.

Kinds of Rope.—Hemp, manila fibre and cotton are the three kinds of rope most used on the Ontario farm. For the hay-fork, the grain slings and hoists, hemp or manila fibre rope are generally used. Cotton rope is limited in its use on the farm to livestock; being softer and more pliable it is desirable for halters and halter shank use. Manila fibre is more pliable than hemp and equally strong. Three strand rope is the type generally used for farm work; however, there is another type, the four strand, that is stronger and more pliable. The four strand weighs more per foot and costs more per pound than the three strand, but everything considered it will give better service than the three strand rope.

Care of Rope.—The losses caused by neglect to whip or bind the ends to prevent fraying, unnecessary wetting, and neglect to dry first before coiling, amounts to about half the original cost each year. That is, a little care would double the life of the rope and cut the annual expenditure for such by one half on the average farm. Mechanical injury to rope may occur to its being subject to overload, or through surface wear, or internal wear and heat. Surface wear is the greatest evil of the four, because in farm work the rope is in frequent contact with the ground, and few farmers appreciate the damage resulting to a rope by dragging it over the ground. Rope dragged over the soil picks up sand or fine grit which acts as a grinding material to cut the fibres and wear the surface. If a rope is to last, all unnecessary friction such as dragging one part over another, or rubbing against beams or posts, or against edges of poorly aligned pulley blocks should be avoided. Internal wear comes from heavy strain and friction, causing the fibres to slide over one another. This also generates heat, which weakens and deadens the fibre to a point where the rope becomes unsafe for any strain. Extreme tension will break fibres, and such generally comes from running the rope over sharp bends, the small pulley in the case of the rope hoist, or the box edge in the case of sling ropes. A sharp bend puts the weight carrying strain on the outer fibres of the rope, removing the distribution of strain from all to the few on the outside, with the result that these weaken or break. For severe hoisting the largest size pulley block possible consistent with the task and a suitable size of rope should be used. To prevent dry rot, the fibres composing the rope should be treated with a lubricant; this makes the fibres pliable and also preserves them by keeping out moisture, a forerunner to dry rotting. During the manufacturing process the fibres used in rope making are treated with a high grade mineral oil. As long as this oil remains injury from dry rot is not likely to occur, but once the oil is gone injury is likely to follow. If the rope becomes dry and harsh because of drying out the application of good lubricating oil, or tallow or fish oil, in quantity no greater than the fibres will absorb, can be used to advantage. Keep acids away from rope as such are destroyers of all fibres used in rope making. When coiling a rope it is usually best to lay it from left to right or in "clockwise" direction, this will generally aid in preventing kinks and twists. However, the direction of coiling will depend upon whether you want to put in or take out the twist. Cases may occur where the coiling would be better done "anti-clockwise." If the rope kinks and twists it is because there is lack of balance between the twist in the strand and the twist in the rope. Rope will not kink or twist if taken from the coil properly, that is "anti-clockwise". This throws twist from the rope. Proper attention to coiling and uncoiling will keep the rope and its strands in balance. See that the rope is free from kinks before making up the grain slings, it will save a lot of trouble.

ROPE DATA.—Manila fibre rope, three strand.

Diameter in inches	1 pound contains		Safe load in pounds	Diameter of pulley to be not less than
	Feet	Inches		Inches
¼	33	4	55	2
⅜	20	0	130	3
½	13	0	230	4
⅝	7	6	410	5
¾	6	1	520	6
⅞	4	3	775	7
1	3	6	925	8
1⅛	2	7	1,260	9
1¼	2	2	1,445	10

Abrupt bending of rope interferes with the distribution of the strain on the various fibres that make up the strands. With a straight pull, a rope will give 100 per cent. efficiency; tie a knot in the same rope and you weaken it as follows:

PER CENT. EFFICIENCY IN ROPE KNOTS

	Per cent.		Per cent.
Square knot in rope	48	Well pipe hitch	78
Overhand " "	50	Carrick bend	77
Weaver's " "	55	Long splice	92
Bowline " "	60	Short splice	96
Double half hitch	73		

WHIPPING A ROPE END

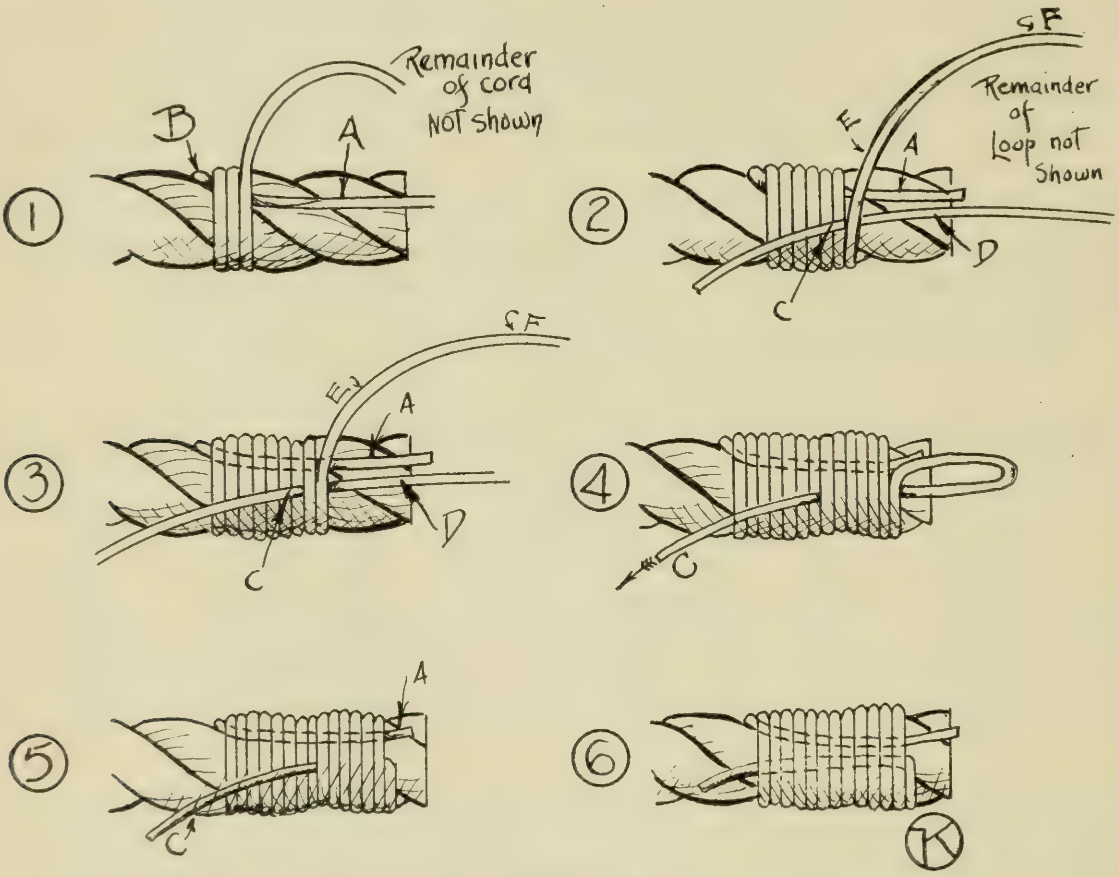
PLATE I.

Figure 1. In figure 1 the end of the cord is laid partly in the outline of the rope as at (B) and then along the rope as at (A). After this carry the cord around the rope and over the part (B A) for a distance of at least half the length you intend to whip.

Figure 2. Having reached this distance place the cord in a long loop. Note that the whipping is about to cover both the end (A) and also that part of the loop that is resting on the rope from (C) to (D).

Figure 3. In this figure the whipping has continued and both (A) and (D) are gradually being covered by carrying the part (E F) around the rope and over the end (A) and (C D).

Figure 4.—Having reached a distance of about half the thickness of the rope from the end, the cord (C) is being pulled in the direction of the arrow so as to draw the remainder of the loop under the whipping.



WHIPPING A ROPE END.

PLATE 1

Figure 5.—The end (C) has been pulled until the loop has disappeared and the whipping fits the rope snugly. The ends (A) and (C) may now be cut off close to the cord.

Figure 6.—If the whipping must be short, the loop may be made before the first turn is taken in which case both ends will be under the full length of the whipping.

THE SHORT SPLICE

PLATE 2

1. Unlay the strands of the ends to be joined for a distance of approximately eight inches (the smaller diameter ropes proportionately less). Whip the ends of the strands.

2. Crotch the two ends together so that a strand of rope (X) is between two strands of rope (Y). The result will look like figure 2, in plate 2.

3. Each pair of strands is now tied together in an overhand knot. For example start with strands (B) and strand 3. Make the overhand knot so that

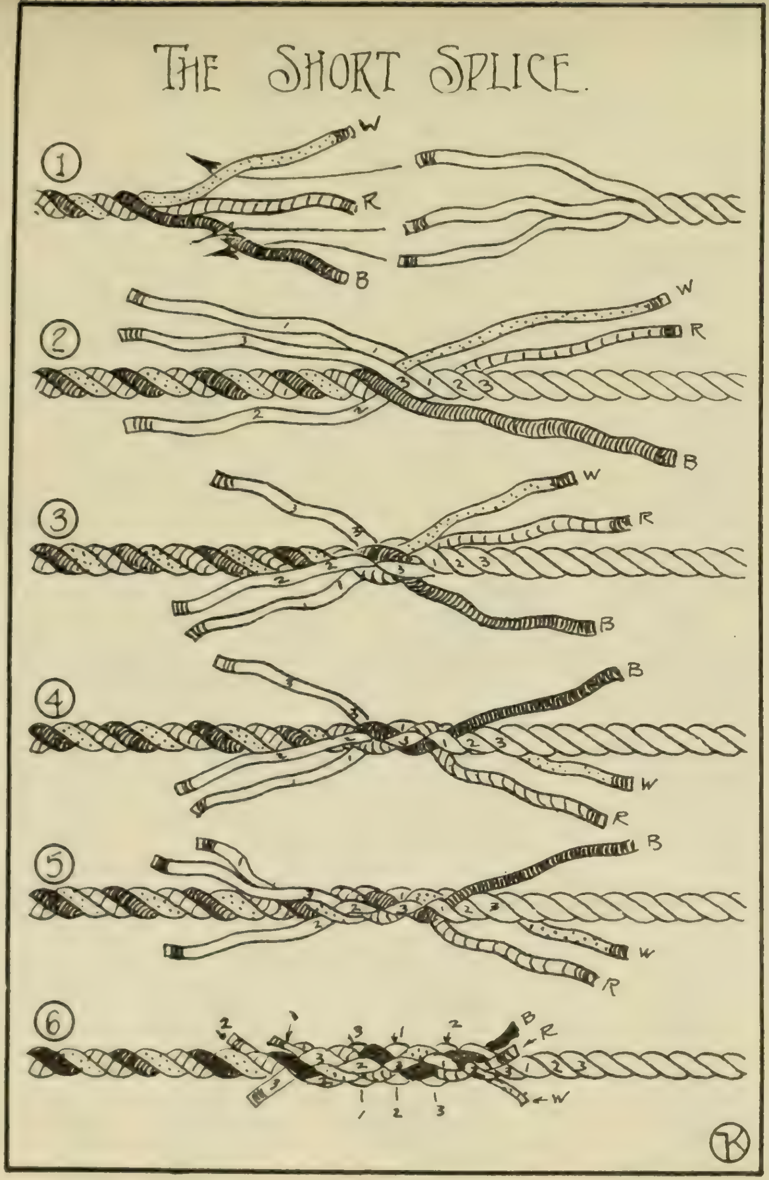


PLATE 2

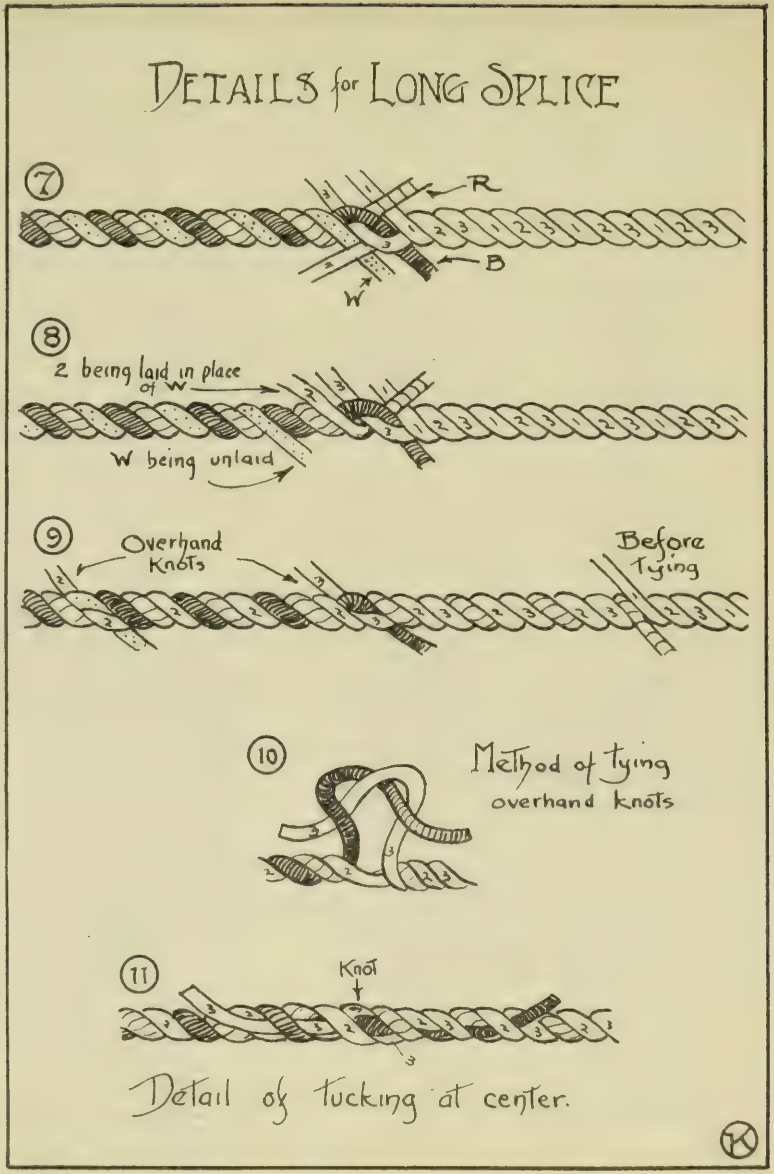

DETAILS for LONG SPLICE
⑦
R
B
W
⑧
2 being laid in place of W
W being unlaid
⑨
Overhand Knots
Before Tying
⑩
Method of tying overhand knots
⑪
Knot
Detail of tucking at center.

PLATE 3

(B) goes first over and then under 3. Draw up snugly. Do this with (W) and (I), and then with (R) and 2. The result will look like figure 3.

4. Give each strand of rope (X) a tuck in this way, to the right.

B to go up over 3 and under 1
R " " " 2 " " 3
W " " " 1 " " 2 (See figure 4. plate 2).

Give each strand of rope (Y) a tuck in this way, to the left.

I over W and under B
2 " R " " W
3 " B " " R (See figure 4, plate 2.

5. To make this stage, see figures 5 and 6, plate 2.

B is passed up over 2 and under 3 to the right.
R " " 1 " " 2 " " "
W " " 3 " " 1 " " "

1 " " R " " W " " left.
2 " " B " " R " " "
3 " " W " " B " " "

Note that in each case you tuck a strand over the one (from the opposite rope) which lies immediately next to it, then under the next. It will be found that with each group of three strands, the last is the one that will be most puzzling, unless the above rule is followed. Usually this carries the tucking far enough. The strands are cut off about one inch long, and left in this condition until the rope has been in use for some time, when they may be cut off flush If a really finished piece of work, in short splicing, is to be done, instead of cutting off the strands, you may cut out one-third of the yarns in each strand, then tuck the remaining two-thirds. Next cut out half the yarns remaining, and tuck what is left. This will taper the splice and make a neat looking job.

MAKING THE LONG SPLICE

Plate 3

The Long Splice is used when the ropes to be joined must run through a pulley block. This splice if made well is nearly as strong as the perfect rope.

1. Unlay the ends to be spliced for a distance of 50 diameters for ropes one inch or under, and 40 diameters for ropes over one inch in diameter. Example: For a rope half an inch in diameter, unlay each part for ½ x 50, equal 25 inches. For a rope one inch in diameter unlay each part 1 x 50, equal 50 inches. For a rope 1¾ inches in diameter unlay each part 1¾ x 40, equal 70 inches. When the unlaying is completed the ends appear as in figure 1 of plate 2.

2. Bring the strands together as in figure 2, plate 2, so that each strand of one rope lies between two strands of the other rope. It is well to place the rope on a table.

3. Tie an overhand knot (study figure 10 first) in two of the strands. It will then look like figure 7. In doing this draw the two parts as snugly together as possible so that there will be no slack part at the centre of the splice. Arrange the other strands as in figure 7.

4. The next step may be followed by referring to figures 7 and 8. Taking one pair of the remaining strands (those to the left of the overhand knot) unlay the one marked (W) and lay the one marked 2 in its place. While doing this try and keep all the rest of the splice undisturbed; you might tie a cord tightly

CROWNING and TUCKING

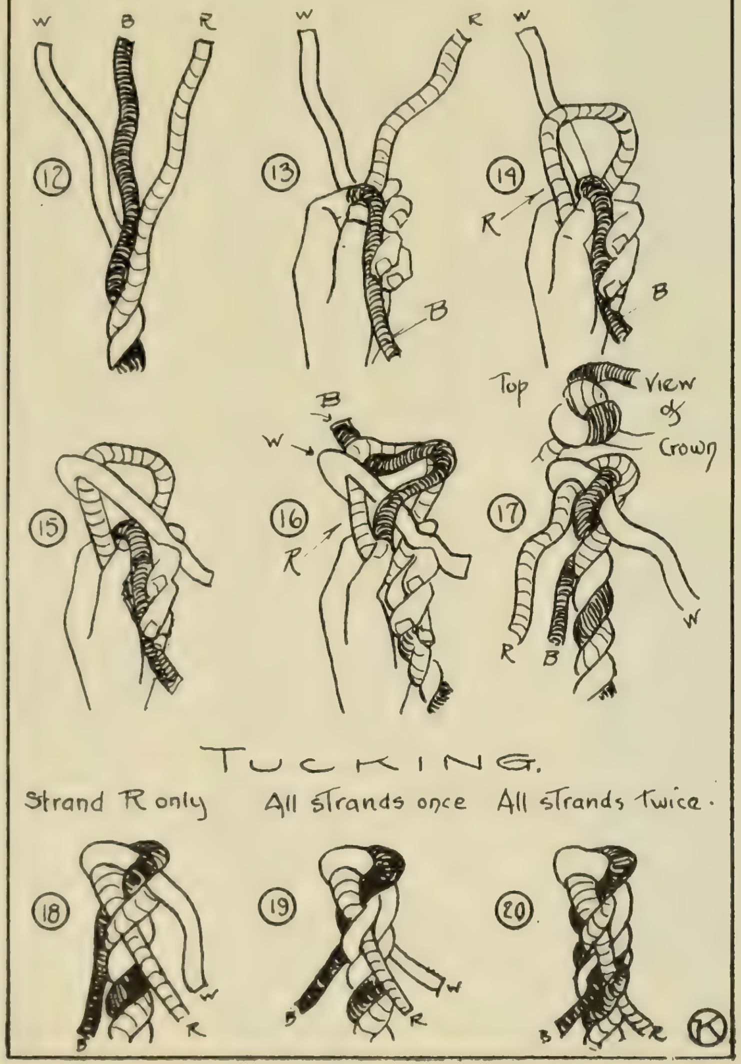
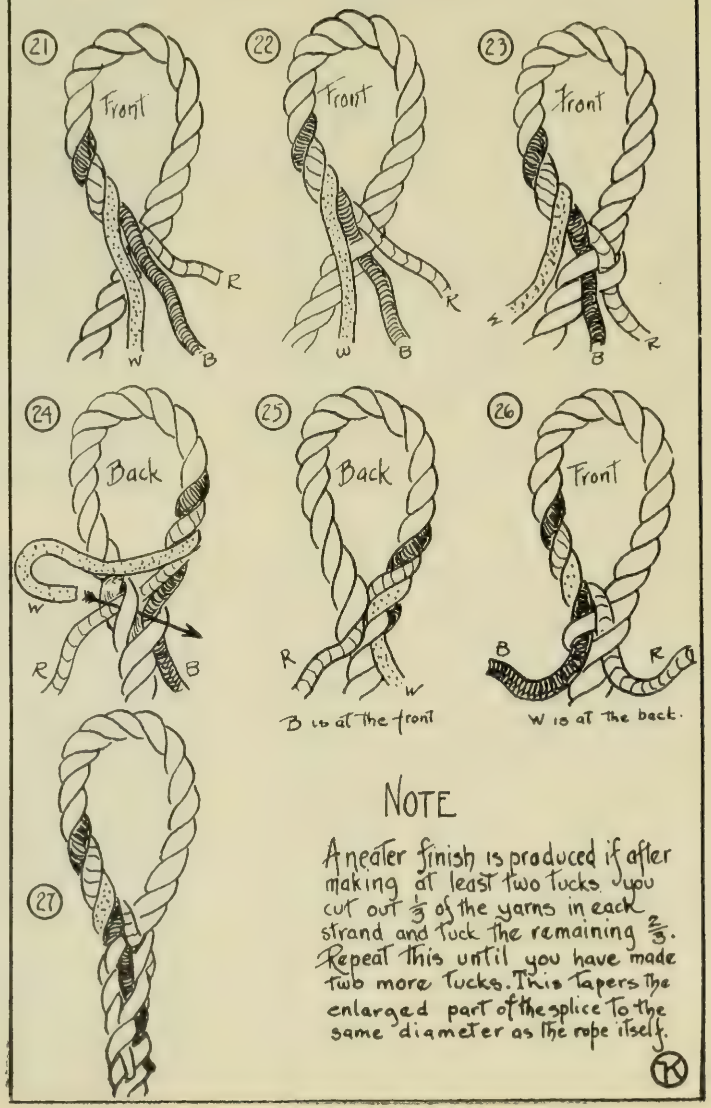


PLATE 4

EYE SPLICE



NOTE

A neater finish is produced if after making at least two tucks you cut out ⅓ of the yarns in each strand and tuck the remaining ⅔. Repeat this until you have made two more tucks. This tapers the enlarged part of the splice to the same diameter as the rope itself.

PLATE 5

around it. In placing strand 2 in position keep it tightly twisted in its own proper lay. Keep doing this until you have but from 6 to 8 inches of strand 2 left. Then tie an overhand knot exactly as before.

5. Cut out the long end of (W) to the same length as 2.

6. Working with the remaining strands, unlay strand 1 and place strand (R) in the groove. Tie and cut as your splice will now resemble figure 9, except that the knots will be quite far apart and all three will be tied and all ends cut to a uniform length of from 6 to 8 inches.

7. You will now tuck these loose ends, being careful to carry the strand in a comparatively straight line down the length of the rope. Tuck it over the strand immediately next to it and under the one following. Make two tucks in each direction. You make more if you wish or you may taper the remainder of the strands and tuck as in the short splice. Figure 2 shows tucking completed at the centre. Note: In tucking, just as you pull the final part of any tuck through, untwist the strand slightly and the tuck will lie flatter.

CROWNING AND TUCKING

Plate 4. This is a most useful way to finish a rope end, it looks well and gives a good grip.

To make the Crown.—

1. Unlay the strands for about five inches, hold the rope in the left hand as in figure 12 so that one of the strands (B) is toward you, place your thumb on this strand and bend it downwards as in figure 13, grasping it with two or three fingers.
2. Now bend strand (R) over into a loop and catch it with thumb as in figure 14.
3. Bend (W) around in front of this looped (R) as in 15 and catch it between the first and second figures as shown.
4. Release (B) and tuck it over (W) and under (R) as in 16.
5. Draw all strands down snugly and the rope will be crowned as in 17.

To tuck the strands.—

1. Take strand (W) and tuck it over (B) and under its standing part, as shown in 18.
2. Tuck (W) over (R) and under its standing part as in 19.
3. Tuck (B) over (W) and under its standing part. This completes the first tucks and the rope should look like 19.
4. The strands are tucked once more in a similar fashion, that is, over the strand immediately below it and under the next. The rope now should look figure 20.
5. The remainder of the tucking is tapered as explained for Short Splice, by cutting one third of the yarns and tucking the remainder.

THE EYE SPLICE

Plate 5

This very useful splice is made as follows:

1. Unlay as for crowning and tucking.
2. Bend the eye and place the three strands as shown in 21 (see plate 5) on top of the standing part.
3. Tuck the centre strand (B) as shown in figure 22.

4. Tuck the strand (R) next to the loop as shown in 23.
5. Turn the eye around so that the back faces you as in 24.
6. Bring the remaining strand (W) around under the strand that crosses (R) and out through as shown by the arrow in 24.
7. Pull all strands up snugly and it will look like figure 25.
8. Turn the loop over and it will look like figure 26 from the front.
9. The strands are now tucked and tapered as explained in "Crowning and Tucking," see plate 4.

Plate 6—(A) The Square Knot. (B) The Weaver's Knot

The Square Knot or Reef Knot is useful in tying two ropes together for temporary use in order to increase length. It can be untied without much difficulty and it will not slip if the two rope ends are the same size and texture.

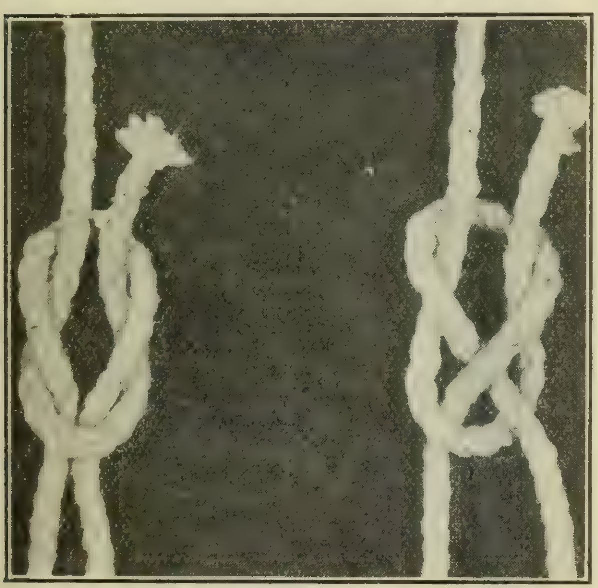


Plate 6

A
Square knot.

B
Weaver's knot.

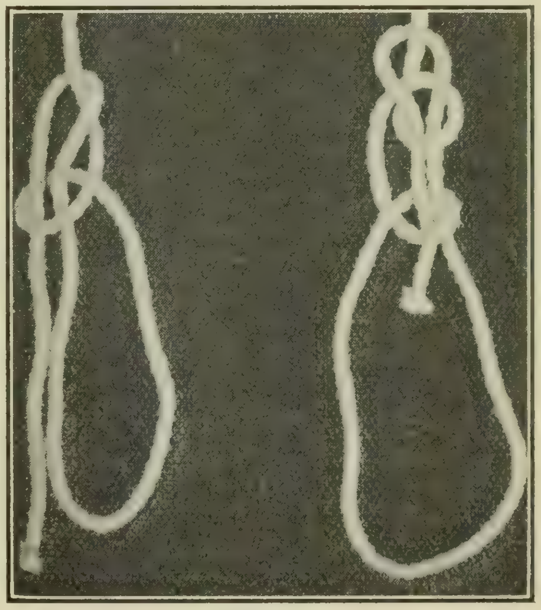


Plate 7

A
Bowline knot

B
Water Bowline knot

The Weaver's Knot or Sheet Bend is very useful in uniting binder twine ends, as it will pass the guides and twine knotter of the grain binder or corn harvester without catching. It is also useful in tying leather straps in making a final repair.

Plate 7—(A) The Bowline Knot, and (B) The Water Bowline Knot

The Bowline Knot is very easy to tie and also easy to untie even when the rope is wet. It gives a non-slipping loop at the end of a rope or may be formed in a bight. It is the best knot for attaching the hay-fork rope to the evener, or any similar work where an easy-to-tie perfectly safe loop is required. The Water Bowline is very useful during ice harvest, if rope is being used to elevate the ice, or wet work.

PLATE 8—(A) THE CARRICK BEND. (B) THE HARNESS KNOT

The Carrick Bend is the best knot to use when joining together temporarily two heavy stiff ropes. Its structure is such that the ends are interwoven to prevent injury to the fibres, abrupt bends are avoided as much as possible.

The Harness Knot is used where a loop is desired in a plough line or other line of any weight, when it is expedient to use an easy-to-tie secure loop, that can be easily undone after having been drawn tightly. The harness knot is also used in making an emergency halter.

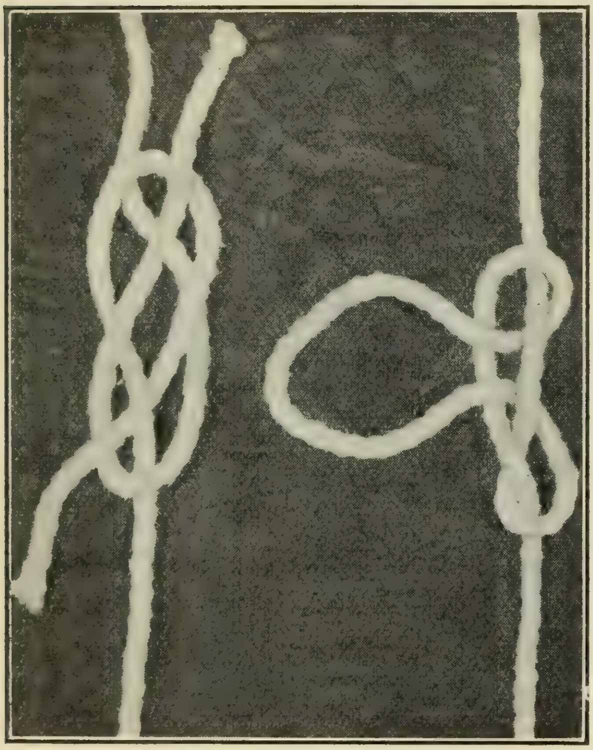


PLATE 8

A
Carrick bend.

B
Harness knot.

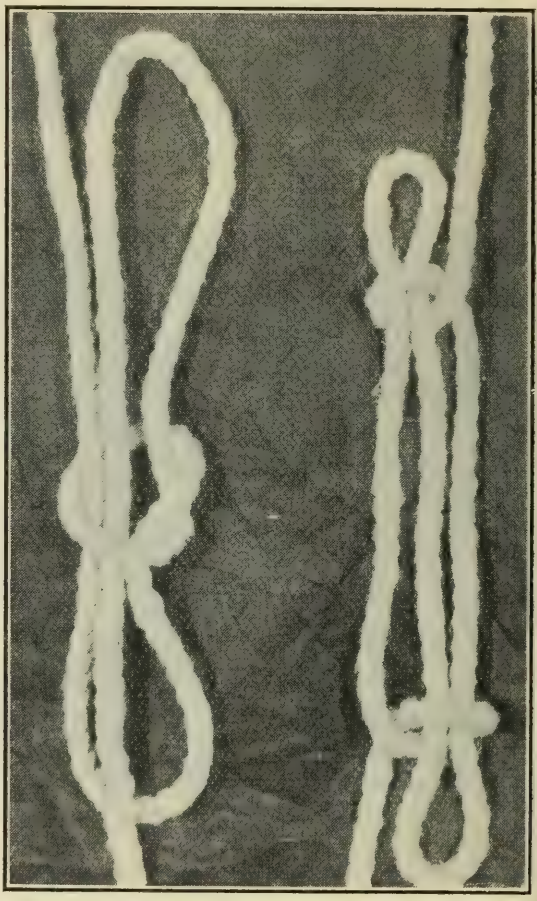


PLATE 9

A
Tomfool knot.

B
Sheep shank

PLATE 9—(A) THE TOMFOOL'S KNOT. (B) THE SHEEP SHANK

The Tomfool's Knot is a most useful knot in handling pigs, when a snare or twitch is desired. One loop may be slipped in the hog's mouth and then tightened by pulling the right rope end. The hog can then be snubbed to post or rail during the pleasure of the operator. The release is important when dealing with pigs, and this knot gives it by simply pulling the other end of the rope.

The Sheep Shank is used where it is desirable to shorten a rope without cutting, such as an overlong hay-fork rope. It is used by steeple-jacks as a means of releasing their safety rope after descending from on high. (One bight is cut through, and the long rope shaken free after the weight is off.)

PLATE 10—(A) THE CLOVE HITCH. (B) THE TIMBER HITCH AND HALF HITCH

The Clove Hitch is used where it is desired to quickly and securely attach a guy rope, or a tie up rope to a post. It is easily made and easily undone. The Clove Hitch followed by a half-hitch also makes a very useful knot.

The Timber Hitch is used wherever timber is being handled. It grips well and is safe and efficient on logs or boards that are being elevated or moved along the ground. It is quickly made and easily released.

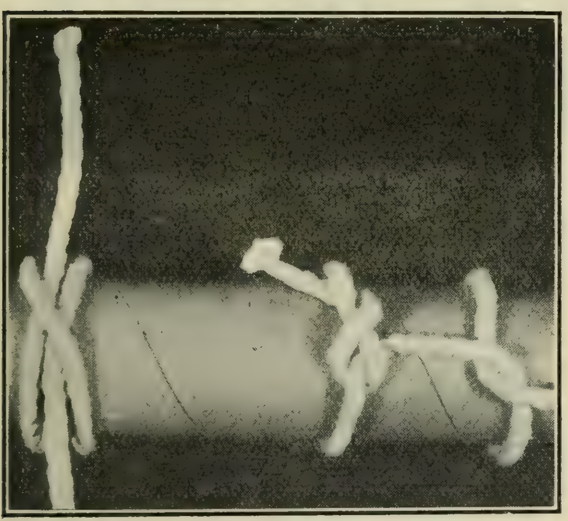


PLATE 10

A
Clove hitch

B
Timber hitch and
half hitch.

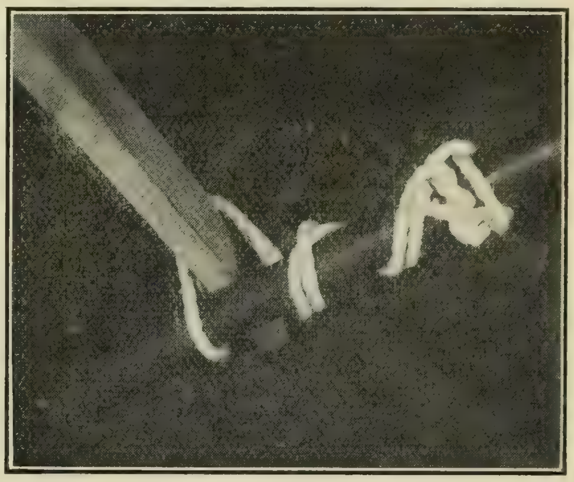


PLATE 11

Barn rafter hitch.

PLATE 11—THE BARN RAFTER HITCH

The Barn Rafter Hitch is a very useful arrangement made by tying a piece of one-half inch rope, about eight feet long, to a light pole 15 feet or more in length. Double the rope in the middle and tie the two ends of the rope to the pole about two feet from the end. The pole is placed beneath the rafter and the loop over it and then over the end of the pole. It is tightened by turning the pole, and released by untwisting or turning in the opposite direction, after the rafter has been nailed in its place.

PLATE 12—WELL PIPE HITCHES

The Well Pipe Hitch is used when a suitable hitch is needed to grip the pump-pipe or log, in lifting it from the well.

PLATE 13—THE SCAFFOLD HITCH

The Scaffold Hitch is used in suspending a plank to be made safe as a scaffold. When properly tied it will prevent the plank shifting its position. The Bowline Knot is a useful knot to use with the scaffold hitch.

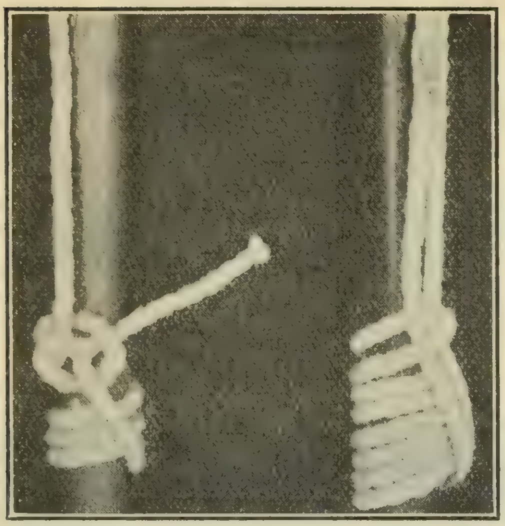


PLATE 12

Well pipe hitches.

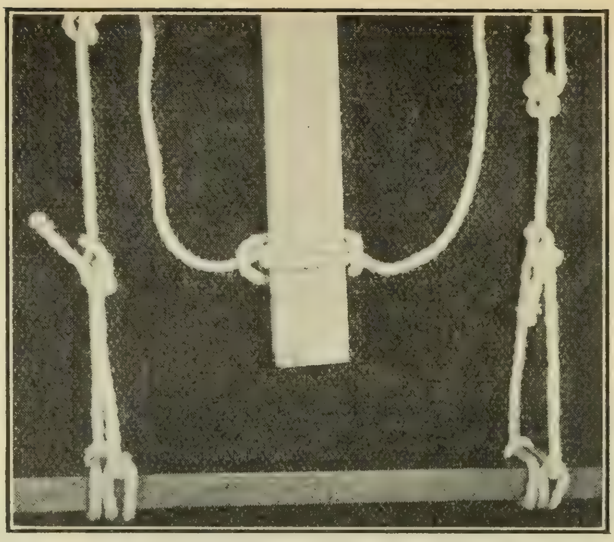
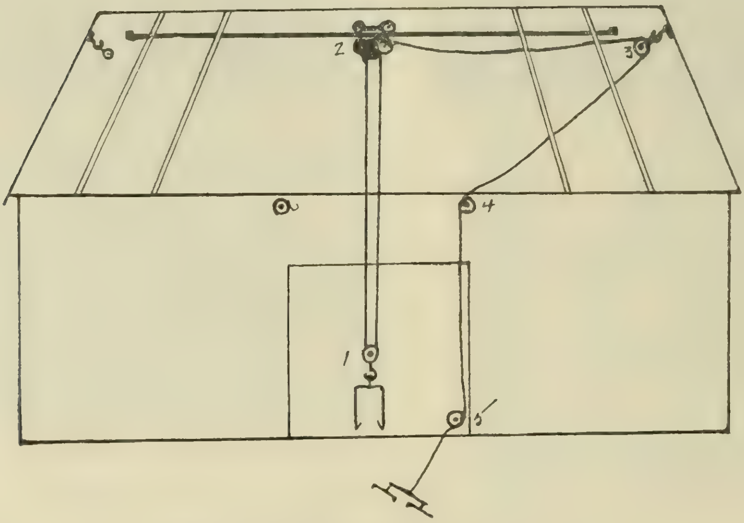


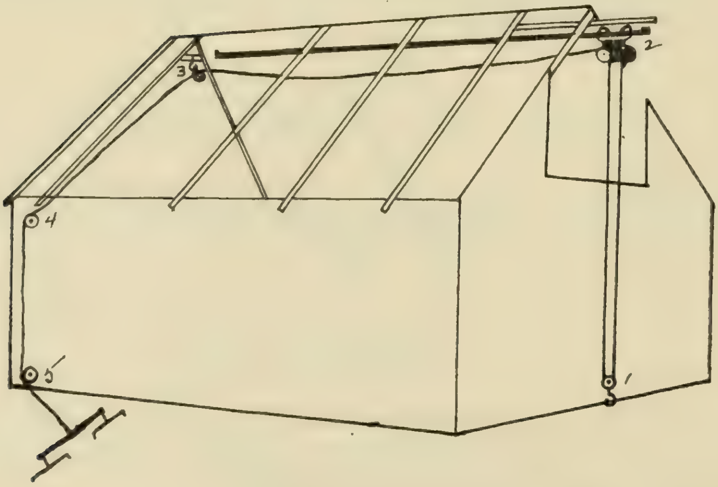
PLATE 13

Scaffold hitch.

PLATE 14.



Rope arranged for a centre-drive barn.



Rope arranged for end-hoist unloading.

PLATE 14—THE HAY-FORK ROPE

To get the length of a hay-fork rope for your barn, measure and add together the following: the distance from 1 to 2, multiply this by 2; the distance from 2 to 3; the distance from 3 to 4; the distance from 4 to 5; and 15 feet extra to provide for heel room and tie. The Bowline Knot makes the best tie in attaching the rope to the doubletree.

PLATE 15—THE EMERGENCY HALTER

The Emergency Halter is made by tying a harness knot at a point about four feet from the end of the rope. This gives the eye and part that goes over the head of the animal. A half-hitch is now made on the opposite side of the animal's head to include the short end rope. A half-hitch is now tied in the short end, to include the long or shank end of the rope. The shank end is threaded through the eye, as shown in plate 15.

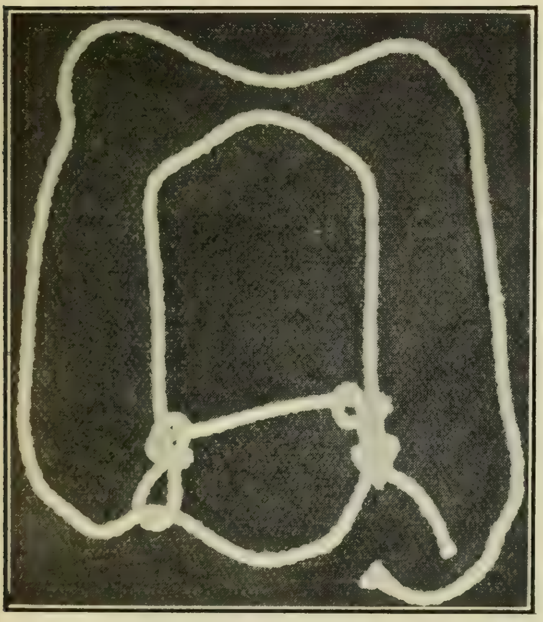


PLATE 15

Emergency halter.
Harness knots and two half hitches used.

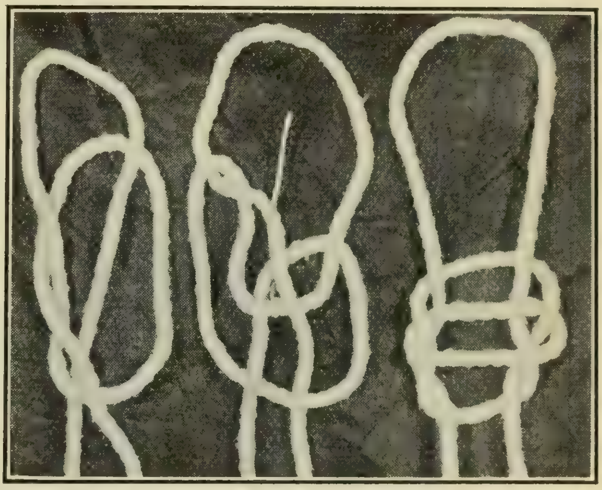


PLATE 16

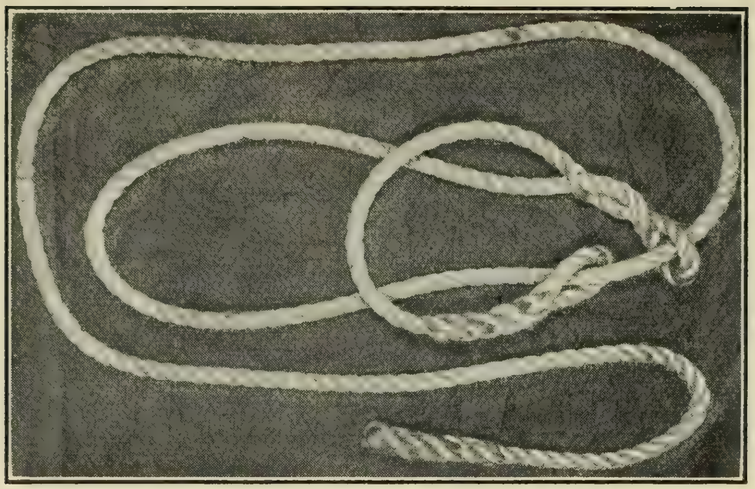
Emergency or Hackamore bridle.
Three stages of make.

PLATE 16—THE EMERGENCY OR HACKAMORE BRIDLE

The three stages in the making of the Emergency Bridle are shown in the plate.

PLATE 17.—The Rope Halter with spliced eye, and crowned end on the shank. (See the section on Crowning and Splicing.)

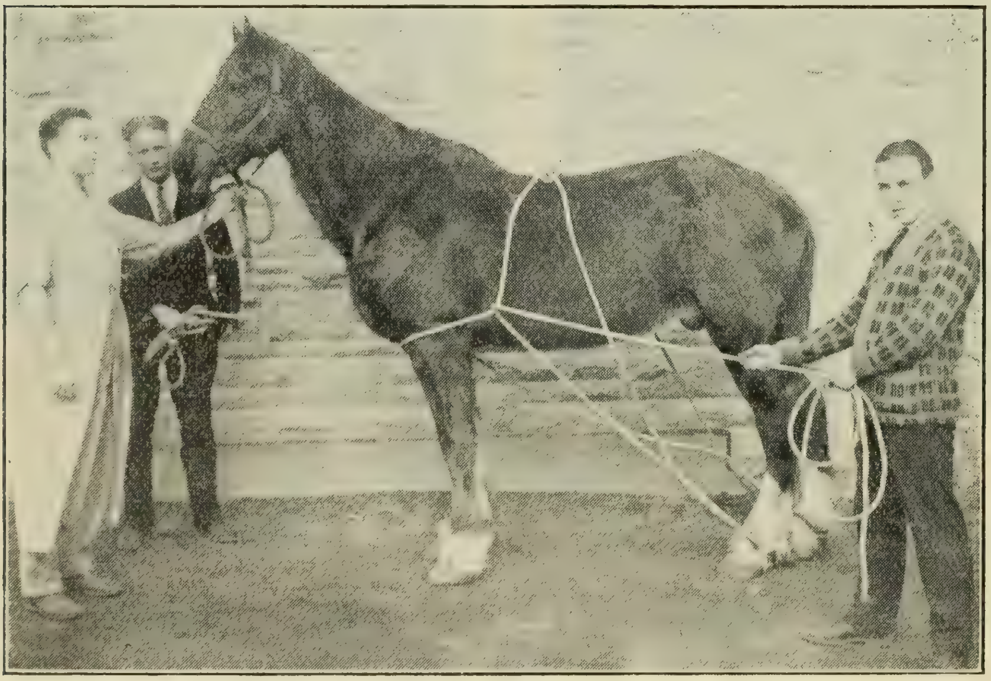
PLATE 17



Halter with spliced eye and crowned end.

PLATE 18.—Rope as used in casting a horse.

PLATE 18.



Rope as used in casting a horse.

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Ontario Department of Agriculture

HORTICULTURAL EXPERIMENTAL STATION
VINELAND STATION, ONT.

The Grape in Ontario

E. F. PALMER AND J. R. VAN HAARLEM

INTRODUCTION

The following pages are written with the hope that they may serve as a help and guide to those who have not had an extended experience with vineyards, and others who may desire to study the subject a little more fully. It is not a presentation of new material so much as an attempt to present a practical outline of grape-growing in Ontario. The information has been gathered from talks with growers in Ontario and parts of New York state, from the wine manufacturers of the province, from various publications dealing with the grape, and from practical and personal experience and observation.

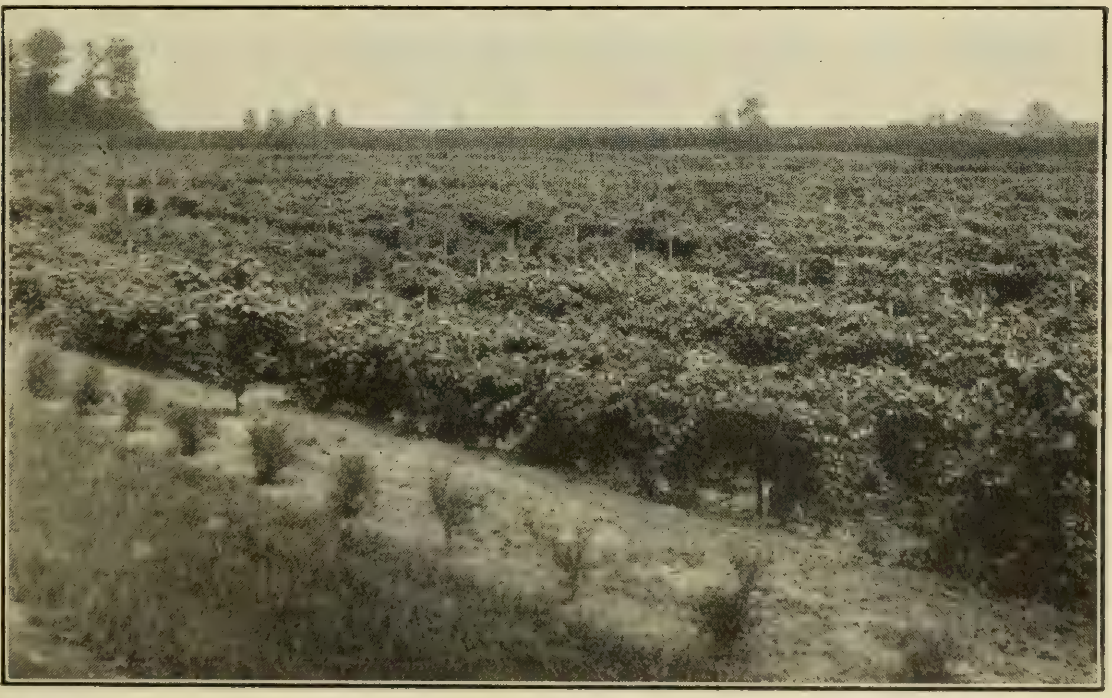


Fig. 1.—General view of a six-acre block of grape seedlings at the Horticultural Experiment Station.

The brief historial outline, gathered almost entirely from the pages of "The Grapes of New York," by Hedrick *et al*, is included for the benefit of those readers who may have a desire to extend their knowledge in this direction. For a more complete and absorbing historical account, readers are referred to the above-mentioned volume.

HISTORY OF THE GRAPE

"The history of the grape is as old as that of mankind." The above quotation and the following paragraphs are taken from "The Grapes of New York," by Hedrick *et al.*

"A single species of the grape is cultivated in the old world. This is *Vitis Vinifera,* the grape of ancient and modern agriculture, the vine of the allegories of sacred record and of the myths, fables and poetry of the old world countries. It is the vine which Adam and Eve cared for . . . . . It is the vine which Noah planted after the deluge; the vine of Judah and Israel, and of the promised land. . . . . . . It has followed civilized man from place to place throughout the world and is one of the chief cultivated plants of temperate climates . . . .

"The history of the Old World grape goes back to prehistoric times. Seeds of the grape are found in the remains of the Swiss lake dwellings of the Bronze Period and entombed with the mummies of Egypt. Its printed history is as old as that of man and is interwritten with it. According to the botanists, the probable habitat of *Vitis Vinifera* is the region about the Caspian Sea. From here it was carried eastward into Asia and westward into Europe and Africa. It is probable that the Phoenicians, the earliest navigators, tradesmen and colonizers on the Mediterranean, carried it to the countries bordering on this sea. Grape culture was developed in this region a thousand years before Christ, for Herod, who wrote at that time, gave directions for the care of the vine which need to be changed but little for present practice in Europe. . . . . .Vergil and Pliny, during Christ's time, gave specific directions for the care of the vine . . . .

"The authentic written history of the grape and of its culture really begins wth Vergil . . . . . The history of the development of the vine from Vergil's time through the early centuries of the Christian era and of the Middle Ages to our own day, is largely the history of agriculture in the southern European countries; for the vine during this period has been the chief cultivated plant of the Greek and Latin nations. This history should furnish most instructive lessons in grape-growing and grape-breeding."

Concerning the history of our North American grapes, Hedrick, in "The Grapes of New York," writes as follows:—"In North America wild grapes abound on the warm, dry soils of New Brunswick and New England, about the Great Lakes in Canada and in the United States, and on the fertile river banks and in the valleys, rich woodlands and thickets of the eastern and southern states. . . . . . They are not so common in the West . . . . .

"It is certain that grapes have not been distributed over North America by the hand of man. Probably they have been growing in the regions where they are now found since before the migration of the first savages."

While there are many species of grapes native to North America, yet comparatively few are represented in the present cultivated varieties of native origin. From the standpoint of Ontario grape-growing, the chief species is *Vitis labrusca,* represented by such varieties as Moore Early, Concord, Worden, Vergennes, etc., which are probably pure labrusca. Niagara, Campbell, Winchell and the "Rogers" hybrids are part labrusca. These "Rogers" varieties, so familiar to all, are the result of crosses between a large fruited variety known locally as Carter or Mammoth Globe (*Vitis labrusca*), and Black Hamburg and White Chasselas (*V. vinifera*), the latter two being the male or pollen parents.

One species, *Vitis vinifera,* is grown commercially in Europe. Compared with our native varieties, the Old World or Vinifera varieties have a higher sugar and solid content, and generally are better flavoured, lacking the acidity and, to many, the somewhat obnoxious foxy odour and taste of many of our native varieties. Because of their higher sugar content and comparatively solid flesh, the European varieties have a long keeping season, a distinct advantage from a marketing standpoint.

In Europe, of course, the grape is used mainly for wine-making purposes. So too, in Ontario, the bulk of the crop finds its way directly or indirectly into native wines. Because of their lower sugar content our varieties are perhaps not as well adapted naturally to wine-making as the European varieties. Nevertheless excellent wines are now being made.

In the early days many attempts were made to grow the European grape in eastern North America. This was quite to be expected, as the Old World immigrants would naturally try varieties with which they were already familiar. These repeated attempts invariably ended in failure owing to the nonadaptability of the species to climatic conditions in eastern America, and to their susceptibility under these conditions to phyllorera, mildew, rot, etc., native parasites to which native varieties are more or less immune. In California, however, the European varieties do well, the Vinifera species being the grape of commerce there. Undoubtedly the more equable climate of the Pacific coast is better suited to this species than the rigorous climate of the east.

North American viticulture, with the exception of California, must continue to depend on varieties derived from our native species. It is to be expected, however, that varieties will eventually be produced through hybridization with the Old World species which will possess all of the good qualities of this species together with the disease-resisting qualities and climatic adaptability of our native species.

The attempts to adapt the Old World varieties to eastern North America conditions delayed for many years the development of our native species. Little progress was made with varieties of native origin until early in the nineteenth century. From that time until the present there has been a steady growth with varieties such as the Alexander or Cape, Norton, Clinton, Catawba, Delaware and Concord giving the necessary impetus.

THE GRAPE IN ONTARIO

In Ontario, grape culture is of comparatively recent origin. The first record of planting that has been brought to the attention of the writer is that of the small area set out on a farm at that time owned by Mr. Porter Adams, at Queenston, in the Township of Niagara, in the year 1857. The next year, Mr. W. D. Kitchen and Mr. J. R. Pettit planted some vines on their farms at Grimsby. In 1862, Mr. Wm. Read, of Port Dalhousie, planted three acres of Concord, Hartford Prolific and Delaware, and in the same year Mr. Peter Wright, of Stamford, planted three acres of Isabella. In 1863, Mr. Lusee, Mr. J. M. Stewart, Henry Lottridge and Christopher Biggar all planted small vineyards. In 1868, Mr. F. G. Stewart, of Stamford, planted two and a half acres of Concord and Delaware, and Mr. Prest, of the same place, planted an acre of Delaware, Concord and Hartford Prolific. In 1869, Mr. Walter Kerr, of Drummondville, planted two acres of Concord and Delaware. In 1873, Mr. D. J. Lowry, of St. Davids, set out two hundred Concord, fifty Isabella, fifty Diana and fifteen Delaware vines. These were set in rows sixteen feet apart and the plants twelve feet apart, and were trained to chestnut stakes seven feet high. No special stimulus seems to have been given the industry until about 1882, when the much advertised "Niagara" variety was introduced. Vines of this variety were sold at $1.25 each, and all cuttings had to be returned to the company. In spite of the high cost, a great deal of money was made from this variety during the years following its introduction.

As late as 1880 the province was credited with not more than 400 acres of commercial grapes. By 1890 this area had increased to 2,400 acres and by 1901 to 5,750 acres. The Dominion census for 1921 does not give directly the number of acres in Ontario, but, based on the total number of vines reported, the acreage would be approximately 7,000. Since the 1921 census there has been a considerable increase in acreage so that it is now estimated that there are about 8,000 acres in the province. Of this total, 7,500 acres are in the counties of Lincoln, Wentworth and Welland, the remaining 500 being chiefly in Halton, Essex and Kent. The distribution, as compiled from the Sixth Census of Canada (1921), is shown in the following table:

Table I—Grapes, Number of Vines, Yield and Value, 1920-21

County	1921 Non-bearing	1921 Bearing	1920 Yield—lbs.	1920 Value
Lincoln	104,909	1,769,826	19,884,823	$1,391,938
Wentworth	59,446	816,001	8,625,593	603,792
Welland	7,697	206,912	2,926,262	207,358
Halton	1,095	54,669	133,662	9,356
Essex	8,057	33,342	187,999	13,160
Kent	2,432	10,085	179,249	12,547
Other counties	13,283	48,903	560,874	36,741
Total for Province	196,919	2,939,738	32,498,462	2,274,892

THE WINE INDUSTRY

Any attempt to discuss the culture of the grape in Ontario must take cognizance of the fact that the bulk of our grapes are now used for wine-making purposes. It is conservatively estimated that fifty-five per cent. of the grape crop is used by the recognized commercial wineries, while a further ten per cent., or possibly more, is eventually made into wine. More liberal estimates place the total of grapes used for wine purposes at from seventy-five to eighty per cent., but such estimates seem unduly high when the figures in the accompanying table are analyzed:

Table II—Ontario Grape Wine Production

Fiscal year ending October 31	Production in gallons	Ontario sales		Exports		Total tonnage grapes used
		Gallons	Value	Gallons	Value	
1923	825,564	370,363	$971,761	362,600	$329,062	4,674½
1924	1,157,371	370,229	896,203	416,747	317,730	5,468
1925	1,245,049	370,362	747,492	655,936	496,508	5,432
1926	4,464,454	521,772	1,023,044	1,474,903	521,423	10,424

The above figures were secured through the courtesy of the Board of License Commissioners for Ontario. Further information for several years previous to 1925 was also given as follows:—"In 1919, when the total number of wineries was from twenty to twenty-five, the estimated gallons sold were 263,310, estimated in value at $411,578.00; in 1920, the corresponding figures were 342,776 gallons and $528,193.00; in 1921, with the object of later getting figures for the provincial fiscal year, figures were asked for the first nine months of 1921, for which period the respective amounts were 195,843 gallons and $346,382.00." These figures, together with Table II, will indicate the rapid growth of the wine-making industry.

The main variety for wine-making purposes is, of course, the Concord. This is natural since this variety constitutes close to seventy per cent. of the total grape acreage in the Niagara district. Other varieties, such as the Niagara for white wines, are used to a lesser extent.

Considerable experimental work needs to be done to determine the best varieties for wine-making, taking into consideration yield and other cultural factors, as well as actual wine-making qualities. The Catawba, for example, is an excellent wine variety, but on account of its late maturity, it is not adapted to the Niagara peninsula though succeeding quite well on Pelee Island (Essex county). The Delaware has been largely used for wine purposes, but for several reasons, chiefly yield and vigour of vine, it will likely never enjoy wide popularity from the growers' standpoint. Both Catawba and Delaware, being red grapes, produce a light-coloured wine.

Elvira, a white grape, was at one time quite popular as a wine grape in the United States. It is hardy, vigorous and very productive. Unfortunately these good qualities are offset by one or two defects, chief of which is the thin skin of the fruit. The skin bursts easily, thus making it a poor shipping variety and also lowering its value as a wine grape. Elvira gives a light, white wine with a slight foxy flavour.

Ives and Norton, two black varieties, have been widely used for wine-making. Neither variety has value for dessert purposes, but from a wine-making standpoint, both should be thoroughly tested in Ontario. The Ives matures with, or just after, the Concord. The Norton is later maturing and on this account may prove to have little value for Niagara peninsula conditions, as full maturity and high sugar content are essential to the production of high grade wines. Incidentally the Norton is a difficult variety to propagate. In the meantime the Concord, in most seasons at least, fills the breach very acceptably as a wine grape. It will likely continue to do so for many years to come particularly as it constitutes such a large part of the present total acreage.

The importance of wine-making to the grape-growing industry has already been indicated.

Previous to 1916 the consumption in Canada of native wines was not great. Since that time, however, there has been a rapid increase in consumption which wine manufacturers have been barely able to meet. Up to the present this does not appear to have been affected by changes in prohibitory laws.

Nevertheless there will be some concern because of the heavy shipments of grapes from the United States. These shipments are for the fresh markets of course, as no grapes other than Canadian grown may legally be used for native wines. However, these heavy shipments tend to depress the market for fresh grapes, since the heavy importing months are August to December, with a consequent lowering of wine-grape prices. Imports of fresh grapes into Canada from the United Kingdom, United States, Spain and other countries are given elsewhere in this bulletin. It will be noted that 1926-27 importations from the United States were very heavy as compared with previous years. This no doubt was due to the very low prices prevailing in United States markets during 1926. Ontario growers have undoubtedly suffered from this apparent overproduction to the south of them.

Further, it should be noted that the export market is still untouched. The production of native wines has as yet been somewhat less than sufficient to adequately care for the home or Canadian market. In this connection it is of interest and value to refer briefly to the Australian grape-growing and wine-manufacturing industries.

In the season of 1924-25 the states of South Australia, Victoria and New South Wales produced a total of 12,350,000 gallons of wine.

South Australia is the chief wine-producing state. The following figures for this state indicate the importance of the industry there.

JUNE, 1925—SOUTH AUSTRALIA

Acreage under wine grapes	29,533 acres
Yield of wine grapes	62,495 tons
Wine made	10,502,381 gallons
Value	£960,632

Compare these South Australian figures with Canadian, or Ontario acreage and production (99.5 of the Canadian grape acreage is in Ontario).

TABLE III—ONTARIO WINE GRAPES, YIELD AND PRODUCTION

	1920	1923	1924	1925	1926
Acreage	7,000	....	....	....	8,000 (est'd)
Yield (tons)	16,000	....	....	....	19,000 "
Used for wine (tons)	....	4,675	5,468	5,432	10,424
Wine production (gals.)	342,776	825,564	1,157,371	1,245,049	4,464,454

The 1926 acreage estimate is based on the Dominion Agricultural Census figures for 1920-21, allowance being made for an increase of approximately 1,000 acres in vineyards since that date. Of the 8,000 total acreage, 7,500 is in the Niagara peninsula. The figures for wine-grape tonnage and wine production were supplied by the Board of License Commissioners for Ontario.

The Ontario acreage figures are for all grapes, whether for wine or market. The South Australian figures are for wine-grape acreage only. Total grape acreage for the whole of Australia is reported to be in excess of 100,000 acres.

Canada, therefore, is manufacturing less than one-quarter as much wine as the one state of South Australia. Moreover, Canada is not exporting whereas Australia as a whole is exporting annually about one million gallons. The actual export figures for Australia are as follows:

1923	706,510 gallons
1924	823,982 "
1925	1,054,460 "

The ability of Australia to export may be due in part to a four shillings government bounty for every gallon exported. In Canada, on the other hand, there is a five per cent. sales tax on every gallon sold whether for export or otherwise. Then on Canadian sales there is an additional excise tax of 7½c. per gallon and an Ontario luxury tax of 50c. per gallon. These taxes do not apply on wine sold for communion purposes, to manufacturing chemists, or direct to the Liquor Commission.

IMPORTS OF GRAPES AND RAISINS

Since 1895 there has been a steady increase in fresh grape imports into Canada. These imports are of course mainly, if not entirely, of the Vinifera or "California" varieties, as they are more familiarly known to the consuming public. These varieties may be found on the fruit stands of our cities at all times during the grape season. They are of distinct quality and flavour, firm, sweet and little subject to rot. The price of this imported product is usually necessarily high, and as they are used for high-class dessert purposes, it is not thought that they compete with the native varieties. Nevertheless there are indications, especially evident in the fall of 1926, that heavy production in California, followed by heavy export to Canada, is going to have a direct and depressing effect on the price of native home-grown varieties. Growers in the eastern United States felt this competition from California grapes very keenly indeed in 1926, very low prices prevailing in the grape regions of New York state. Returns generally were probably little better than half those secured in Ontario—$59.00 per ton.

The following table of imports of grapes, mostly from the United States, is therefore of considerable interest:

Table IV—Imports of Fresh Grapes into Canada

Year	Quantity	Value
1895	977,754	56,118
1900	936,344	55,327
1910	3,502,989	221,887
1915	6,200,160	317,183
*1923	11,202,740	874,941
*1924	10,965,517	862,298
*1925	12,565,121	826,531
†1926	16,766,546	928,744

*Dominion fiscal year, April 1st-March 31st.
†Ten months, April, 1926-January, 1927 (inclusive).

The bulk of the above imports (over 90 per cent.) are, of course, from the United States. The large 1926 crop in the United States and the parallel lower prices are clearly indicated in the following figures:

Table V—Imports of Fresh Grapes from the United States

Year	Quantity in lbs.	Value	Average Declared Value per lb.
*1923	10,469,102	$773,348	C.7.39
*1924	9,479,571	683,603	7.21
*1925	11,549,342	703,178	6.09
1926 (10 months)	16,305,114	855,724	5.25

*Dominion fiscal year.

It will be seen that each year since 1923 there has been a decrease in the declared per pound value of the imports, the low figure of 5.25c. for 1926 being appreciably lower than that for any previous year. The trend of values is perhaps more clearly portrayed in Table VI, where the per pound values of the heavy importing months are given separately, not averaged with the low import, high-price winter months. Thus September values were successively 7.19c., 6.78c., 6.05c. and 5.09c. for 1923, 1924, 1925 and 1926, respectively. Similar October values were 6.74c., 6.16c., 5.15c. and 4.06c. Thus there was a steady decline year by year for both months. In 1926 it will be noted that the low 4.06c. value for October rose during November to 5.36c., yet the imports were practically the same for both months, 4,805,694 pounds in October and 4,521,246 pounds in November. It is evident that the diminishing seasonal supply of Ontario grapes favoured a corresponding increased price for the imported product. Other similar instances could be given. For example, November, 1925, imports were over thirty per cent. greater than for October of the same year. Yet the average customs declared value advanced from 5.15c. for October to 6.16c. for November. Apparently then the native and imported grapes do compete with one another, for, if native grapes affect the price of imported stock the reverse must be equally true.

TABLE VI—IMPORTS OF GRAPES INTO CANADA FROM THE UNITED STATES—AVERAGE VALUE PER POUND BY MONTHS

	1923-24	1924-25	1925-26	1926-27
April	c.42.12	c.36.20	c.27.52	c.28.59
May	33.12	27.63	24.71	24.50
June	32.71	26.58	21.98	26.16
July	19.03	15.25	14.01	9.04
August	8.84	7.09	5.82	5.51
September	7.19	6.78	6.05	5.09
October	6.74	6.16	5.15	4.06
November	6.64	7.66	6.07	5.36
December	8.13	8.34	6.13	6.08
January	11.14	14.82	7.58	10.76
February	21.07	27.44	12.87	.....
March	17.32	41.04	21.22	.....

The above figures have been calculated from figures secured from the Department of Trade and Commerce, which give the total imports and the total value of same, month by month.

With the tremendously increased grape acreage both in California and the eastern States, there is every indication that the present diversion of California grapes to Canada will at least be maintained and probably increased. What the effect of this will be on the price of Canadian-grown grapes is perhaps not entirely clear, but it does seem probable that it will have a depressing effect as in 1926. The lower prices of 1926 cannot be entirely ascribed to the late season and imperfect maturity of our own grapes. Heavy imports are at least partly responsible and must be reckoned with in future.

It may be suggested, of course, that since the imported grapes are entirely for dessert purposes, and since Ontario grapes are mainly used for wine purposes (65 per cent.), that the price of the former, however low, would not influence the price of our own grapes. It must not be forgotten, however, that the price of wine grapes is not set independently but is determined by the market price for fresh grapes.

Referring again to Table VI, it is interesting to compare the declared customs values ranging as low as 4.06c. per pound with the usual retail selling price of the imported grapes. Imported grapes were retailing in St. Catharines during October, 1926, at twelve cents per pound or at the rate of about eighty-five cents per our six-quart basket. Considering the nature of the imported grape, this may certainly be considered a competitive price. The retailer could probably well afford to sell at comparatively low prices as the price to importing wholesalers during 1926 reached as low a figure as $35 per ton f.o.b. California shipping point. This is one and three-quarter cents per pound.

Further, as to competition, it is often thought that California grapes do not enter Canada in any great amount during the height of our own grape season. Customs entries, however, show that, while some grapes are imported during every month of the year, yet by far the heaviest importations are during the months of September, October, November and December. During the remaining months imports are comparatively negligible.

Raisins are imported into Canada chiefly from the United States, Spain and Turkey, though Turkish shipments seem to be falling off. On the other hand steadily increasing amounts are coming from Australia, shipments from this country ranking ahead of Turkey for the first time in 1926. Imports during the past few years were as follows:

TABLE VII—IMPORTS OF RAISINS, DRIED, INTO CANADA

	Years ended March 31st			Eight months ended Nov. 30, 1926
	1924	1925	1926	
From United Kingdom	210,949	154,121	635,040	998,137
" United States	35,690,194	41,232,094	31,006,435	25,314,018
" Australia	29,502	158,458	75,555	685,091
" Greece	96,251	111,380	11,300	49,294
" Spain	1,444,992	1,547,270	1,658,863	910,101
" Turkey	1,149,741	1,151,469	377,365	407,726
" Other countries	170,410	66,840	47,174	218,337
Total pounds	38,792,039	44,421,632	33,811,732	28,582,704
Value	$3,222,162	$3,157,677	$2,325,285	$2,157,208

SELECTION OF VARIETIES

Possibly it is of little value to analyze the variety question at any great length inasmuch as the Concord so completely overshadows all other varieties. While actual figures are, of course, not available a careful estimate of grape plantings by varieties, made by an individual in close touch with the industry for some years past, is as follows:

Concord	67%	Champion	2%
Niagara	12 "	Moores	2 "
Worden	8 "	Campbell Early	1 "
Rogers'	7 "	Various	1 "
			100%

Thus the Concord is estimated to constitute two-thirds of the total acreage. That this estimate closely approximates the actual plantings is indicated by the following figures of sales of grapevines by one of the larger Ontario nurseries:

TABLE VIII—SALES OF GRAPEVINES, 1919-1926

Year	Agawam	Campbell Early	Concord	Lindley	Moore Early	Niagara	Worden
1919........	1,046	358	27,253	292	1,738	2,656	4,639
1920........	618	349	21,223	673	1,127	6,679	7,086
1921........	455	1,311	39,135	726	937	3,401	7,171
1922........	3,439	2,345	165,124	2,127	1,970	17,662	17,156
1923........	6,991	2,081	96,352	415	2,610	7,039	13,935
1924........	2,636	1,560	110,035	683	1,815	10,504	17,532
1925........	582	624	69,516	157	1,361	7,787	12,665
1926........	1,336	1,458	90,793	166	1,347	13,961	7,917
Total.....	17,103	10,086	619,431	5,239	12,905	69,689	88,101
Percentage...	2.08	1.22	75.31	.64	1.57	8.47	10.71

These figures, of course, are for recent plantings. They indicate a still higher proportion of Concords than the 67 per cent. estimated, but the old-established vineyards probably contain a relatively higher proportion of varieties other than the Concord. This is indicated in that the planting of the Rogers' hybrids, for example, are known to have fallen off considerably in recent years. Also the estimate and the nursery figures are not strictly comparable as the latter give sales for only two Rogers' varieties, Agawam and Lindley, and further do

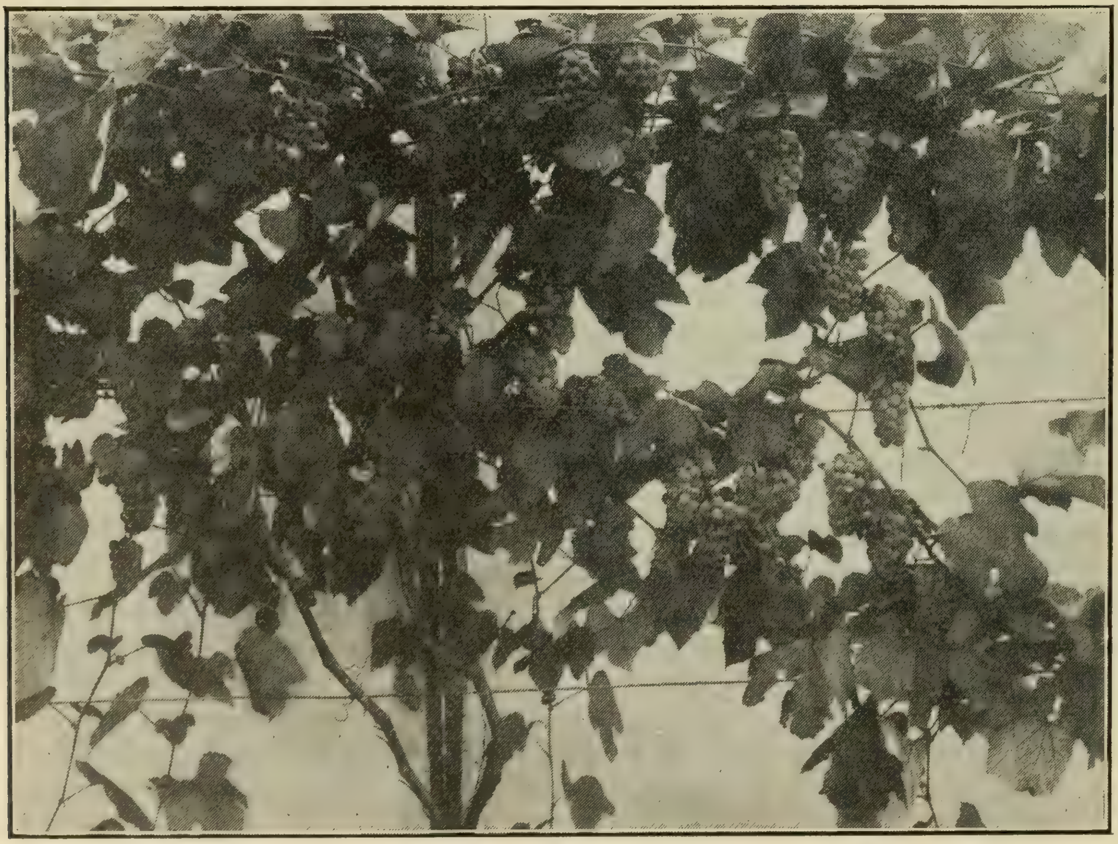


Fig. 2.—The Patricia grape, a new variety originated near St. Catharines, Ontario.

not take into account sales of miscellaneous varieties. Nevertheless the preponderance of Concord is evident, with Niagara and Worden following far behind.

In discussing varieties, the ultimate purpose of the fruit, whether for dessert or wine, should be carefully considered. The variety question from the wine standpoint has already been briefly discussed in the section of the bulletin dealing with the wine industry. Further varietal discussion at this time will have reference primarily to fresh grapes for the market, and ostensibly to be used for dessert purposes.

While the Concord now dominates the fresh-fruit trade even as it does the wine industry, yet it is likely that new varieties will be introduced from time to time which will be more desirable for dessert purposes. If varieties can be originated which, while possessing adaptability to our climate, combine with this adaptability something of the general quality, flesh-type and long-keeping characters of the "European" or "California" varieties, then it would seem possible to displace some of the imported product. There is an ample market here, too, as imported grapes for the calendar year 1926 amounted to over 16,000,000 pounds or almost half of the estimated Canadian grape yield. Some of our present varieties, such as Campbell, Lindley, Herbert, etc., possess European variety characters to a certain extent. Unfortunately such varieties are inclined to fall short in other ways. Generally, however, it would seem desirable in future grape plantings to give more attention to better dessert varieties. Given the right type of native grape the dessert market should be capable of very considerable expansion, partly at the expense, of course, of the present heavy imports.

It is recognized that some educational work will be required to bring about the above suggested condition, even when the right type of native dessert grape is available. It must not be forgotten that the Canadian buying public up to the present has been "educated," in so far as native grapes are concerned, to the Concord and similar varieties with their more or less "foxy" odour and taste. The average purchaser has learned to expect this characteristic in native grapes; he has perhaps acquired a taste for it and may not take any too kindly to native varieties of less pronounced "foxiness." The writer has at various times taken urban visitors through the Horticultural Experiment Station vineyard. It is a peculiar fact, but none the less true, that, with few exceptions these visitors, who know few if any varieties by name, prefer the "foxy" grape, though admitting that the Herbert, for example, is a nice grape. Yet the Herbert represents a type of grape, possessing *Vinifera* characters, such as firmness of flesh, high quality, freedom from foxiness and long-keeping, in considerable degree.

In the selection of varieties, roadside marketing should also be considered. Such varieties as Winchell and Brighton are of doubtful value where shipment to market is necessary. For local sale as from the roadside market, however, their thin, easily-broken skin would not affect their sale. And their quality is such as to commend them to the most critical.

RECOMMENDED VARIETIES

Wine—Concord, Worden, Niagara.

Market—Moore, Campbell, Lindley, Worden, Diamond, Niagara, Concord, Herbert Agawam, Vergennes.

Roadside Markets—Winchell and Brighton, in addition to any or all of above.

POLLINATION

In the above lists there are three varieties which are often called "Rogers' Hybrids." There are Lindley (Rogers' 9), Agawam (Rogers' 15) and Herbert (Rogers' 44). Of these three, Agawam is self-fertile or self-fruitful, so that it may be planted without reference to cross-pollination. Lindley and Herbert, however, and also Brighton, are *self-unfruitful.* Therefore, in planting, provision must be made to include with them good pollinators such as Concord and Niagara, or in fact any of the other varieties recommended, all of which with the exceptions noted are self-fruitful and good pollinators. Brighton apparently is easily cross-pollinated as it almost invariably sets good crops of large, well-filled bunches. Lindley and Herbert are not so easily pollinated as, even where ample provision has been made for cross-pollination, the bunches are apt to be straggly and the yield light.

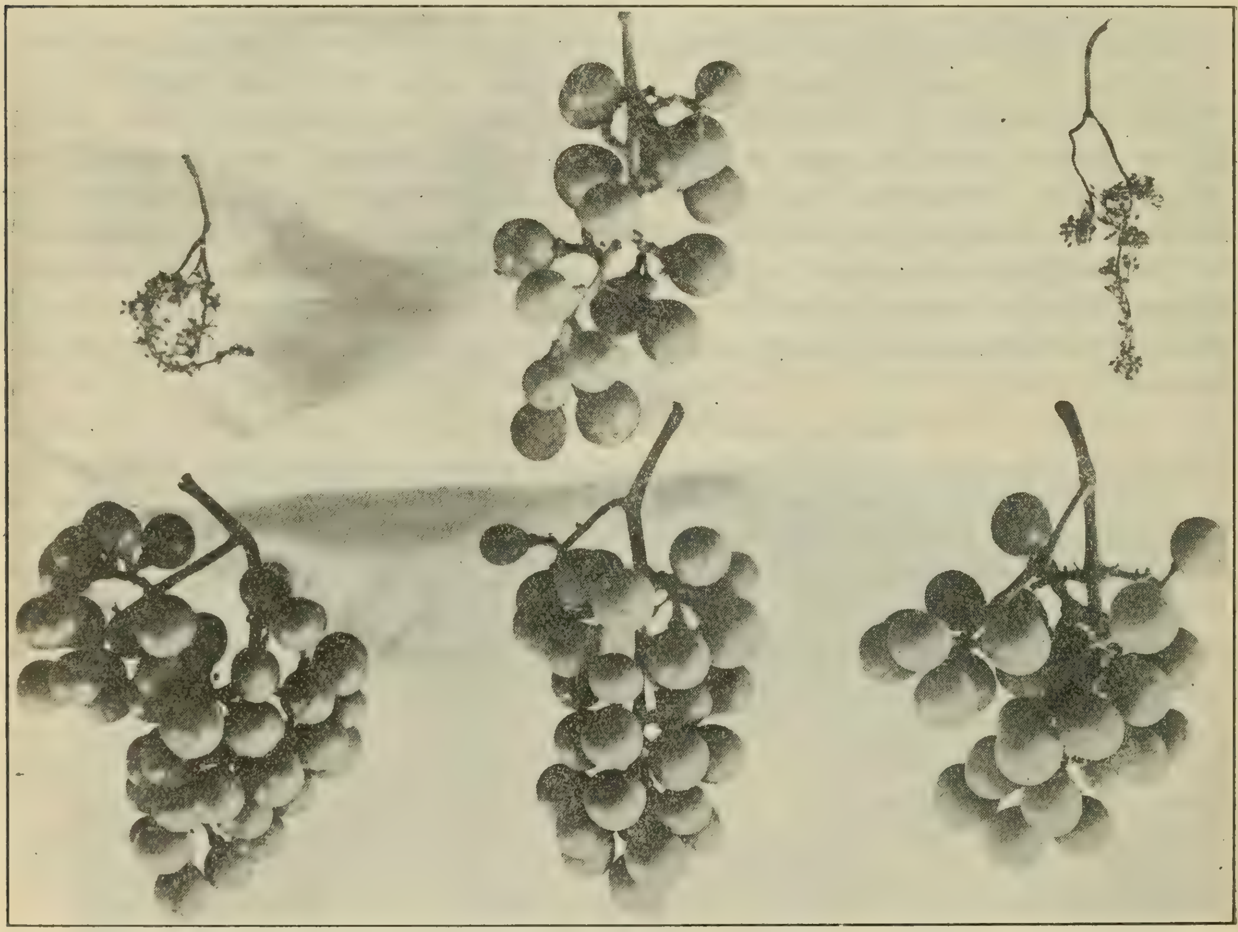


Fig. 3.—Grape self-fertility tests. Left to right, Salem, Agawam and Massassoit. The three upper bunches were self-fertilized, the three lower bunches cross-fertilized. With the exception of Agawam, the Rogers' varieties require cross-pollination.

Further more specific varietal notes are given in the following paragraphs, the varieties being arranged alphabetically.

Agawam (Rogers' 15).—This is a red-fruited variety resulting from a cross of Carter or Mammoth Globe (red Labrusca) with Black Hamburg (Vinifera). Because of its self-fruitfulness, Agawam is probably the most widely planted and popular Rogers' hybrid. It is vigourous, though subject to mildew, usually hardy, and moderately productive. Bunches and berries are large and attractive in appearance. In flavour it is rich, sweet, but decidedly foxy. It also falls somewhat short in fruit characters in that the skin is thick and the pulp rather coarse and solid. The fruit keeps excellently in storage.

Brighton.—This variety, often incorrectly referred to as a Rogers' hybrid, is of particular interest in that it is a secondary Vinifera-Labrusca hybrid. It was originated by Jacob Moore, of Brighton, N.Y., from a cross of Diana Hamburg, a Vinifera-Labrusca hybrid, crossed with Concord, a pure Labrusca. Brighton is vigorous, productive, adapted to varying soil conditions, and, for a vinifera hybrid, relatively resistant to fungi. In season it is considerably earlier than Concord. The bunches are attractive and larger than those of most native varieties. The medium-sized berries are well and not too compactly distributed. In quality it is excellent, being among the best, if not the best, of the varieties of native extraction. Unfortunately it deteriorates rapidly after picking, and, in addition, the skin is very thin, easily broken, and the variety therefore not adapted to shipping. For the amateur there is no more attractive variety. Also for local and roadside marketing it should find a ready and profitable sale.

Campbell Early.—This variety was originated by Geo. W. Campbell, of Delaware, Ohio. It is a seedling of Moore Early pollinated by another production of Campbell's, a Belvidere-Muscat Hamburg seedling. It was introduced in 1892. Were it not for capriciousness as to soils, Campbell Early would be widely and deservedly popular as an early variety. Unfortunately it reaches perfection on light, deep soils only and is therefore often referred to as a "sand" berry. When thus grown it has many fine qualities. In season it is ten days to two weeks in advance of Concord. The vine is hardy, vigorous and productive. The bunches and berries are large and attractive, blue-black in colour. The quality is excellent when mature, being free from foxiness and from acidity about the seeds. Because of the fact that it colours well in advance of maturity, it is often picked too early and its reputation suffers in consequence. The fruit keeps and ships well.

On the heavier soils, such as our grapes are usually planted on, Campbell Early is anything but satisfactory. It falls off in productiveness; the fruit on individual bunches matures unevenly and over a long season, unripe fruit in Concord season being quite common; and the bunches are apt to be poorly filled, straggly and variable in size. Thus Campbell Early falls short in that it has not the elasticity of constitution of many other native varieties which permit of their being grown under varying conditions of soil and climate. On the right soil however, deep and comparatively light, Campbell Early is an excellent early variety.

Concord.—This variety was originated by E. W. Bull of Concord, Mass., from the seed of a wild grape planted in 1843. It was introduced in 1854. The Concord is the most popular and widely grown grape in Ontario, constituting close to 70 per cent. of the total acreage. The outstanding character which has given to the variety its present popularity, is its adaptability to varying soils and climatic conditions. It is everywhere productive, irrespective of soil type.

Though not high in quality, and possessed of a foxy taste, yet Concord is well liked as a table grape. The fruit is an attractive blue with heavy bloom; bunches are of good size, regular and well-filled. Concord, which is a pure Labrusca, does not ship or keep well as compared with varieties possessing

Vinifera blood, such as Campbell, Agawam, Herbert, etc. It is inclined to shell rather badly if held for any length of time. The place occupied by the Concord in the production of wine has already been noted.

Diamond.—Originated about 1870 by Jacob Moore of Brighton, N.Y. Diamond has made its way slowly but surely as a meritorious green grape. It is a seedling of Concord, fertilized with Iona, a Labrusca-Vinifera hybrid. Though not as well known or as widely planted as Niagara, it falls little if at all short of that variety in general all-round desirability. Compared with Niagara, Diamond is somewhat less productive, fully as hardy and vigorous, and slightly earlier in season. In fruit character it has many of the qualities of both Vinifera and Labrusca, yet at the same time possessing a sprightliness not found in the former, and lacking the foxiness of the latter. In vine characters it is wholly Labrusca. Though it is now grown in the Niagara District to a considerable extent, Diamond deserves even wider recognition from both commercial and amateur growers.

Herbert or *Rogers' 44.*—Is a sister seedling to Agawam, arising from the same cross made by E. S. Rogers in 1851. Of the "Black Rogers" Herbert is probably the best. When well-grown and properly mature it is hardly surpassed in quality among varieties derived, in part at least, from our native species. Considering all things, hardiness, vigor, early season, large size and handsome appearance of fruit, keeping and dessert qualities, Herbert is probably the finest table grape so far evolved in the amelioration of our native grapes. As with most black grapes the fruit colours somewhat in advance of maturity, and when thus picked there is an astringency that wholly disappears with proper maturity. The variety keeps excellently for many weeks in ordinary cool cellar storage. It is worthy of attention from growers who cater to markets which appreciate high quality grapes of native origin. The Herbert has not the sweetness, perhaps, of Vinifera or "California" varieties, but it has a sprightliness with its richness of flavour which does not cloy the appetite as do the Vinifera varieties. As previously indicated Herbert is self-unfruitful, and therefore requires interplanting with good pollinating varieties such as Concord and Niagara.

Lindley or *Rogers' 9.*—Resulted from a cross of Carter (a red Labrusca, and White Chasselas (Vinifera). Lindley would be unsurpassed as a red grape were it not for the fact that it is self unfruitful. Cross-pollination is necessary, but unfortunately, provision for cross-pollination does not always insure that it will take place. Too often weather conditions may not be to the liking of bees and other pollen carrying insects. Of the Rogers' varieties, Lindley seems the most difficult to cross-pollinate successfully. Yet when pollination is effective there is no more desirable red grape than the Lindley. The crop is good, the bunches are of good size, the berries are large, uniform and attractive, being a clearer brighter red than other "Red Rogers," and the quality of course is excellent—fine-grained, juicy and tender without evident pulpiness. The skin is relatively thin as compared with other Rogers' Hybrids, but is tough and does not crack easily, so that the variety is an excellent shipper and keeps well. In vine characters the Lindley is very vigourous, hardy and healthy, though subject of course to mildew. In addition it is perhaps somewhat capricious as to soils. Nevertheless, even with this lack of adaptation, and with its self-unfruitfulness, Lindley is popular with many growers. Of late years, Agawam, because of self-fruitfulness, has been more extensively planted than Lindley. A self-fruitful Lindley would be a boon to grape growers.

Moore Early.—This variety, probably a seedling of Concord, was originated by John B. Moore, of Concord, Mass., and was introduced in 1877. Though lacking somewhat in vigour and in adaptability to varying soil conditions, Moore Early still remains our standard early blue grape. Moore Early is much like its parent variety, Concord, differing mainly in season, vigour and productiveness. It has not the robustness of constitution of the Concord, requiring more careful culture if satisfactory crops are to be secured. The bunches are good in size and medium only in quality, though much superior to that other early blue, the Champion, which it should entirely displace. From a marketing standpoint Moore Early must be handled quickly as, once the fruit is cut, it deteriorates very quickly.

Niagara.—This variety, a seedling of Concord, was introduced in 1882 by the Niagara Grape Company. Due to the advertising given the variety, and the method of dissemination whereby the above company retained control of the stock for many years after its introduction, Niagara jumped into immediate popularity. This advertising, which subsequently proved to be overadvertising, counted against the variety in the long run. Nevertheless it is our most popular and widely grown white grape. It would probably be more popular if it were allowed to ripen properly before being picked. The vine is vigorous, moderately hardy, as productive as Concord but more subject to disease. The bunches are large, surpassing Concord in this respect, and well-filled, almost too well-filled in fact, being so tight and unyielding that individual berries are easily crushed in handling. In flavour Niagara possesses the typical Labrusca foxiness, liked by some and not by others. As with any variety of grape it must be fully mature before its full flavour is developed. Then it is good in quality.

Vergennes.—Vergennes originated as a chance seedling in the garden of William E. Greene of Vergennes, Vermont. It is a red fruited variety and probably a pure Labrusca. Owing to its many good characters, particularly heavy and regular bearing, and excellent shipping and keeping qualities. Vergennes has steadily increased in popularity. It requires relatively heavy pruning, else it will overbear, thus delaying its season and giving poorly coloured fruit. Overbearing also will induce biennial bearing in this variety. When well-ripened the fruit is an attractive red. Because of this late ripening, due to insufficient pruning, and also because of its somewhat straggly habit of vine growth, Vergennes is not popular with some growers. If sufficiently pruned, however, so that the crop is of moderate proportions, Vergennes will mature about in Concord season. With an overload the season will drag on for ten days or more. Though not of the highest quality, Vergennes is sufficiently good, and in addition it is an excellent keeper, probably surpassing all other pure Labruscas in this respect. It is a self-fruitful red grape, another point very much in its favour, since cross-pollination is not necessary.

Winchell or *Green Mountain.*—Was originated in Vermont about 1850 from seed of an unknown purple grape. It was introduced in 1888. The variety is included in the recommended list mainly because of its early season and high quality which should make it an admirable grape for the roadside market. Unfortunately it is not suited to anything but local markets as the thin tender skin of the fruit is very easily broken. In vine characters Winchell is usually vigorous, hardy and productive. New vines are often somewhat slow to establish themselves, but once started, do well. The bunches ordinarily are quite large, though varying in this respect, and rather loose. The berries are below medium in size being somewhat too small for a first class commercial grape. In quality Winchell is of the best, sweet, melting and without foxiness.

Worden.—The Worden, another Concord seedling, was originated by Schuyler Worden, of Oswego County, New York, from seed planted about 1862. Were it not for the fact that due to its tender skin, the fruit often cracks badly, thus rendering it unfit for marketing, Worden would be a strong competitor of Concord. Compared with the parent variety, Worden is equally hardy, vigorous and productive, though probably somewhat less adaptable to varying soils. Both bunches and berries are larger than Concord, of better quality, and about a week earlier in season. The earlier season is of considerable importance in the Niagara District, as weather conditions at times prevent varieties of the Concord season or later from maturing properly. Worden has another weakness, not previously mentioned, which is that the berries sometimes fail to colour properly, retaining a purplish immature tinge.

Other Varieties

There are a number of good varieties other than those in the foregoing list, which might well be added to it. However, the thought has been to reduce the number of recommended varieties as much as possible and yet have a representative list with varieties covering the season and suitable for all purposes. Among varieties which might have been included are, Delaware, Salem and Wilder.

Delaware.—A red grape, is well known to both grower and consumer. In quality it is without equal amongst our native varieties, equalling the vinifera or old world varieties in fact. Because of this it justly commands a premium as a dessert grape on most markets. Delaware falls short in vigor of vine, yield, and size of bunch and berry. Vigor and yield can be offset largely by close planting, but the small size of the bunch and fruit must always count against the variety. In addition the foliage is quite susceptible to mildew. Another difficulty is that birds are very partial to the clear-skinned, attractive looking, high quality fruit, with the result that all exposed bunches are likely to be so badly damaged as to entirely prevent their sale. As a wine grape Delaware has been widely used and much sought by wine-makers. Whether for wine or for dessert, the variety, if it be successfully grown, must have more than ordinary care and attention. Requisites are, a deep rich well-drained soil, close planting, thorough cultivation and relatively heavy pruning.

Salem.—Salem or Rogers' 22 might well have been included in the recommended list were it not for the fact that this list already contains four red grapes, Agawam, Brighton, Lindley and Vergennes. Salem is self-unfruitful, as are also Brighton and Lindley. It must therefore be interplanted with a good pollinating variety. Salem is a sister hybrid to Agawam and Herbert, the parents of all three being Carter and Black Hamburg. Of the Salem, Hedrick, in "Grapes of New York" writes as follows: "Salem is one of the Rogers' hybrids of which the originator is said to have thought most and to which he gave the name of his place of residence. Taking all of its characters, the variety is as close an approximation to the ideal Rogers had in mind of an European grape and an American vine as any one of the score or more of his hybrids. Salem ranks among the best of these hybrids for either the garden or the commercial vineyard, and while commonly found in both it has not been sufficiently recognized by those who grow grapes for the market. It is difficult to say why it is not more largely grown as a market fruit in New York. The two chief faults, unproductiveness and susceptibility to mildew, are not found in all localities, and in these at least and especially near good markets, Salem ought to take high rank as a commercial fruit."

Wilder or *Rogers' 4.*—Is another of the Carter-Black Hamburg hybrids. It is rated as being one of the most dependable of the Rogers' Hybrids, being vigorous, hardy and moderately productive. As in the case of all the Rogers' varieties excepting Agawam, Wilder is self-unfruitful. Wilder falls somewhat short of Herbert, a sister "Black Rogers," in quality, and as the Herbert is almost equally dependable in vine characters and is usually superior in appearance, Herbert rather than Wilder has been included in the recommended list.

In addition to Delaware, Salem and Wilder there are a number of other varieties grown to some extent at least in Ontario, which should be mentioned. These are Barry, Catawba, Champion, Lincoln, Lucille, Massasoit, Moyer and Pocklington.

Barry (*Rogers' 43*).—Is a black fruited variety of distinctly high quality, resembling Black Hamburg, one of its parents, in many particulars. It is an excellent keeper.

Catawba.—A red grape, once much favoured for wine-making, requires too long a season to mature properly in the Niagara Peninsula. It has done well however, in Essex County, particularly on Pelee Island.

Champion.—Should be mentioned only to condemn it. It is grown as an early variety, but like so many grapes, colours long before it is mature. Champion is generally credited with destroying public confidence in grapes, a reputation which it undoubtedly merits. At its best it is distinctly poor in quality. At its worst, which is its usual condition since it is almost invariably picked before fully ripe, it is decidedly poor and sour.

Lincoln or *Read's Hybrid.*—Originated with Wm. H. Read of Port Dalhousie, Ontario. It does well apparently on the lighter, deeper soils such as Campbell Early requires. On the heavier soils its performance to date has not been so promising.

Lucille.—Is probably a seedling of Wyoming. In vine characters, such as vigor, health, hardiness, productiveness and adaptability to soils it is unsurpassed by any other variety of native origin. Bunch and berry are attractive in appearance but lack in quality unless one prefers a decidedly foxy odor and flavour. Flesh characters also are undesirable. It is inclined to overbear in which event the fruit will be of poor colour instead of the normal rather attractive red. In season it precedes Concord.

Massasoit (*Rogers' 3*).—Another "Red Rogers" and the earliest in season of the Rogers' Hybrids. As a commercial variety it does not measure up to the standard set by the other named Rogers' varieties already mentioned.

Moyer.—This is another variety originated by Wm. H. Read of Port Dalhousie. It greatly resembles Delaware, one of its parents, but, except in season which is earlier, and in hardiness, it is doubtful if it measures up to the standard Delaware.

Pocklington.—The Niagara has pretty well displaced Pocklington as a white grape, primarily because the former is earlier in season and therefore a more certain performer. When well matured Pocklington is good both in appearance and quality.

NEW VARIETIES OF GRAPES

The grape variety question should not be closed without some reference to several new varieties which are beginning to attract attention. Among the more promising may be mentioned Patricia, Fredonia, Ontario, Portland, and Sheridan. With the exception of the Patricia these are all productions of the New York Agricultural Experiment Station, Geneva. Fairly extended description of each variety is included herewith so that Ontario grape growers may become familiar with their characteristics.

Patricia.—Originated with Wm. Baccus of St. Catharines, Ontario. It has been under test at Vineland since 1915, and gives promise of being a valuable addition to the early blue varieties. Patricia matures with or just after Moore Early, but is much superior to that well-known variety in vine characters. It is healthy, vigorous and productive. The bunches are large and of medium compactness. Quality is fair to good though the flesh is somewhat pulpy. When this variety is finally introduced it should be given extensive trial.

The descriptions of the following Geneva productions were secured from the New York Agricultural Experiment Station.

Fredonia.—This variety, a black grape, originated as a cross of Champion x Lucile. It is better than either parent as an early variety, ripening fully a week earlier than Moore Early. Compared with Moore Early, Fredonia is more attractive both in size and colour, and of better quality, being little if any below Worden in this respect. The skin of Fredonia is tough, suggesting that it will prove a good shipper. The fruit keeps well on or off the vine. In vine characters Fredonia is superior to Moore Early, being vigorous and productive.

Ontario.—Ontario is a cross between Winchell and Diamond which comes in season a little before Winchell, hitherto the best early green grape. Bunches and berries are larger and more attractive in appearance than those of either of the parents, the bunches are not quite so compact, and unlike those of either parent are usually single-shouldered. The vines are more vigorous and more productive than those of Winchell or Diamond. The grapes hang on the vines long after ripening. It should supplant Winchell as an early green grape.

Portland.—Ontario, described above, takes first rank as an early green grape for home use, and Portland, ripening at about the same time, holds first place among the grapes as an early green variety for the market. The vine in this variety is particularly satisfactory, as it is very vigorous, hardy, productive, and healthy. The variety is remarkable for its luxuriant and persistent foliage. Bunches and berries are larger than those of any other early green grape and quite equal in size to the bunches and berries of Niagara. The quality is better than that of any other native green grape excepting Ontario which it does not equal.

Sheridan.—A hybrid of Herbert and Worden, is probably the most valuable grape the New York Agricultural Experiment Station has yet sent out—the only one that may surpass Concord as a commercial grape. Wherever Sheridan has been grown under the same conditions as Concord, the plants have been found to be just as vigorous, healthy, and hardy, to bear as regularly, and to be even more productive than those of the older variety. The bunches of Sheridan are larger and more compact, with a firmer skin, and berries as large as those of Concord; the flavour is sweeter and richer. The season is a week later and the grapes do not shell as readily, so that the crop can be kept longer than that of Concord. It only remains to be seen whether or not Sheridan will thrive in as great a diversity of soils as Concord. The vines are productive to a fault.

LOCATION AND SITE

Examination of the table of acreages by counties previously given, indicates that the grape centres are largely in those sections which come under the influence either of Lake Ontario or Lake Erie. It is evident that for the best varieties and for commercial culture some protection from extreme cold is necessary. Grapes, however, thrive fairly well without winter protection in the greater part of Western Ontario though favouring proximity to large bodies of water.

Before taking up the somewhat narrower question of site there should be some discussion of the more general subject of location. Location is of extreme importance. In the Niagara Peninsula, wherein is grown the bulk of Ontario's grapes, the general aspect is north facing the waters of Lake Ontario with the so-called "mountain" or escarpment in the rear. There the crop naturally varies but never entirely fails. The favoured spots in this general location are not on the shore of the lake, but rather just below and on the first bench of the escarpment where the water has less influence. In vineyards close on the lake the fruit sometimes fails to ripen well with consequent inferior quality. If the volume of water were smaller, the influence would be sufficient for frost protection only. As it is however, it retards development in the spring and further prolongs the period from the commencement of growth in the spring to maturity of fruit in the fall, owing to its cooling effect during the summer months. Depending on the direction of air currents, there is often a difference of several degrees in temperature. This water influence is striking on other fruits as well as grapes. Peaches for example often ripen a week later on the shore than two to four miles inland. In seasons such as that of 1926 when even the most fortunately situated vineyards barely matured their crops properly, delayed maturity becomes a matter of the utmost concern.

There are, of course, several factors which are conductive to late maturity of the fruit. Those which have to do with soil types will be treated of in the discussion of Soils. Where the short growing season is a normal climatic condition it cannot be overcome except by planting earlier and quicker maturing varieties. In other cases, where it is due to abnormal weather conditions such as obtained in 1926, it cannot be overcome by direct means. The sowing of a quick-growing cover crop such as oats, may assist, but ceasing cultivation and allowing the weeds to grow and the canes to ripen, is often all that can be done.

The particular site is of importance for several reasons chief among which are air-circulation and natural soil drainage. Good air-circulation, and of course sunlight, assist the grower in his fight against disease. Disease can live to advantage only in conditions which favour it, and light and air are its hereditary enemies. Then as to soil drainage little need be said, other than to emphasize that a warm, dry deep soil is essential to early maturity and high quality.

The danger from early frosts in the fall is largely one of site. Low-lying flat land suffers first. Cold air settles in such situations, while more elevated or rolling situations are always more or less affected by air currents. Cool air flows down and away from them making them relatively frost-free.

SOILS

Confining ourselves to the commercial areas, we find that grapes are successfully grown on a great variety of soils under varied conditions. Good vineyards are to be found on the clay soils of Vinemount, Beamsville and St. Catharines, the mountain wash of Winona, the black muck of Homer, the sandy loams of Jordan, Vineland and Port Dalhousie, the sand of Fonthill and the gravel in the Burlington district. Nevertheless certain general soil preferences should be noted. Also individual varieties have soil preferences as indicated in the variety discussion.

Site has been shown to influence date of maturity. A cold soil also is often a main cause of slow or delayed maturity. Coldness is largely due to the water content of the soil. Grapes thrive best on the warmer, drier soils where the fruit matures earlier with consequent higher sugar content and quality. A moist, cool sand, ideal for strawberries and raspberries, often fails to properly mature the grape, and even in favourable seasons does not give as high a sugar content as the heavier soils. On the other hand the harder, heavier clays ripen the grapes early as a rule. An exception, the Fonthill sand, will be noted later. Underdrainage will make the cool sands warmer, but the undertaking is considered inadvisable as these soils are more valuable when planted to small fruits.

Two types of soil give large crops of high quality grapes. These are the silty soils in the various townships found below the escarpment in the Niagara Peninsula, and the soils of the first ledge of the escarpment mapped in the soil survey work as Dunkirk clay loam. The former is of a grey or black colour and from six to nine inches deep underlaid with a heavy subsoil of bluish or drab coloured clay. Where the proportion of organic matter is greatest, the soil is darkest and most open and friable. This type of soil is derived from glacial lake deposits and occupies low-lying areas. The Dunkirk soil is dark brown to greyish brown clay and clay loam, about eight inches in depth, somewhat hard and cracks on drying. Owing to its nature it is usually easy of drainage, but the subsoil is hard and impervious to water. The grit and gravel well mixed with the greater part of this soil tend to keep it more loose and open than it otherwise would be. The exception to these two types of grape soils is found in the warm, drier sands such as are found in the Fonthill district and scattered in various other parts of the grape-growing areas.

A part of the grape soils of New York State are of this nature. Warmer, drier, natural conditions, tend to early ripening and good quality. The quantity is possibly somewhat lower, but the warmth is an insurance against non-maturity.

In Michigan also, grapes do best on loams, sandy loams, or sand, but here again the soil type is more like that of the Fonthill area. In Michigan, according to Bulletin 121, Grape Production in Michigan, "The heavy types of soil cause a very heavy vine growth and later ripening of fruit. This is a disadvantage in years with early fall freezes. On the other hand, the heavy soils produce a heavier tonnage of grapes than do the lighter soils. The very sandy soils produce vines of poor vigor and consequent lower fruit yields. Grapes mature earlier, however, when grown on the lighter soils."

The difference in maturity, etc., under Michigan soil conditions, as compared with Niagara Peninsula conditions is best shown by reference to grape maturity tests made by the Horticultural Experiment Station in 1916 and 1917. For the purpose of these tests, fruit was secured from every grape area between Burlington and the Niagara River, and from the various soil types. Repeated visits were made to selected vineyards during the ripening season so that the maturity of the varieties under test could be traced. Also in as far as possible all districts were visited within a two-day period so that the development on the various soils might be fairly compared.

The results obtained confirm the statements already made with reference to maturity of grapes on Ontario soils. Grapes grown on the heavier soils matured earlier than those grown on the lighter soils. This was particularly noticeable in 1917 when all grapes were late in maturing. Only those on heavier soils were really fit for marketing when the early frosts came. Further, it should be noted that increased elevation tended to overcome soil influence. Thus Vinemount clay, unlike most other clay soils, produced a slow maturing grape. In both years, 1916 and 1917, the muck soil of Homer produced the highest quality fruit.

·PLANTING

Preparation of the Soil

As for all our commonly grown fruits, thorough preparation of the soil before planting is advisable. It is poor practice to set vines in sod land plowed under the previous fall. If grapes must be set on old sod land it should be summer fallowed the fall preceding planting, and plowed again in the spring at the time of planting. To thoroughly prepare and clean land for grapes it is best to grow some hoed or grain crop the year before planting. Then as soon as the land is dry enough to work in the spring it should be well worked with a disc and spring tooth cultivator.

· Distance of Planting

Distances of planting vary very much throughout the grape district. They range from 12′ x 10′ and 10′ x 10′ to as close as 8′ x 8′ and 8′ x 7′. These differences are due to variations in the soil, and variations in the vigour of the varieties of grapes. Vines planted on the lighter, sandy soils, require more feeding space than the same varieties planted on clay or clay loam. Such varieties as the

Niagara and Lindley are far more vigorous, requiring longer pruning than either Moore Early or Delaware; and hence must be farther apart in the rows than these latter varieties.

The distance between the row has been practically fixed to nine or ten feet, the smallest space in which a wagon can pass conveniently down the rows to gather the fruit, or in which a tractor can operate to advantage.

For the standard varieties, as Concord, Niagara, Vergennes, Worden and any of the Rogers' varieties, a space of nine and a half to ten feet between the rows and nine feet in the rows is recommended. For the less vigourous, smaller growing varieties, as Moore Early and Delaware, a space of nine and a half to ten feet between the rows and seven or eight feet in the row is sufficient on average grape soil.

A practical plan to increase the yield per acre is to plant the rows closer, eight feet apart. By this means enough ground will be gained over the regular ten-foot planting to set an extra row of vines every fourth row. The difficulty of gathering the fruit with a standard wagon can be overcome by using a special grape truck which measures four feet ten inches over all in width. Because of the cross reaches used on these trucks they can be turned easily in a space fifteen feet wide. Tractors, of course, cannot be operated in such closely planted vineyards. For tractors ten feet between rows is advisable.

ALLEYS

In vineyards which are to cover an area of five or more acres, alleys running crosswise of the rows should be provided at intervals. These facilitate cultivation and make shorter hauls possible during the picking season. These alleys should be wide enough to permit turning with a two-horse wagon.

NURSERY STOCK

In ordinary nursery practice grape vines are propagated from hardwood cuttings. The cuttings may be prepared any time after the vines are dormant, but, other things being equal, and provided they are afterwards well cared for, the sooner they are taken after the vines become dormant the better. The majority of grape growers do not grow their own vines but buy them from nurserymen. A few of the large nurserymen grow their own vines to propagate from; others gather their cuttings from nearby commercial and varietal vineyards. Unless the grower is experienced in the propagation of grapes he would be well advised to use nursery-grown stock.

The wood for cuttings is gathered from the vineyards shortly after pruning. Cuttings are made from well-matured wood of the same season's growth; and preferably from short-jointed, medium-sized wood of about one-quarter inch diameter. Cuttings are usually made three buds, or about ten to twelve inches long. A cut is made a half-inch or so below the lowest bud, and another about an inch above the third or fourth bud. The cuttings are then tied in bundles of convenient size, the buds all turned the same way; then heeled in or buried in trenches, butt ends up, and covered with three to six inches of soil. Inverting the bundles causes the butts to callus while the tops remain dormant.

In the spring, as soon as the soil is dry, warm enough and thoroughly worked, these cuttings are set two to three inches apart in furrows three to four feet apart. The furrows are usually made on a slight slant, and are deep so that when the

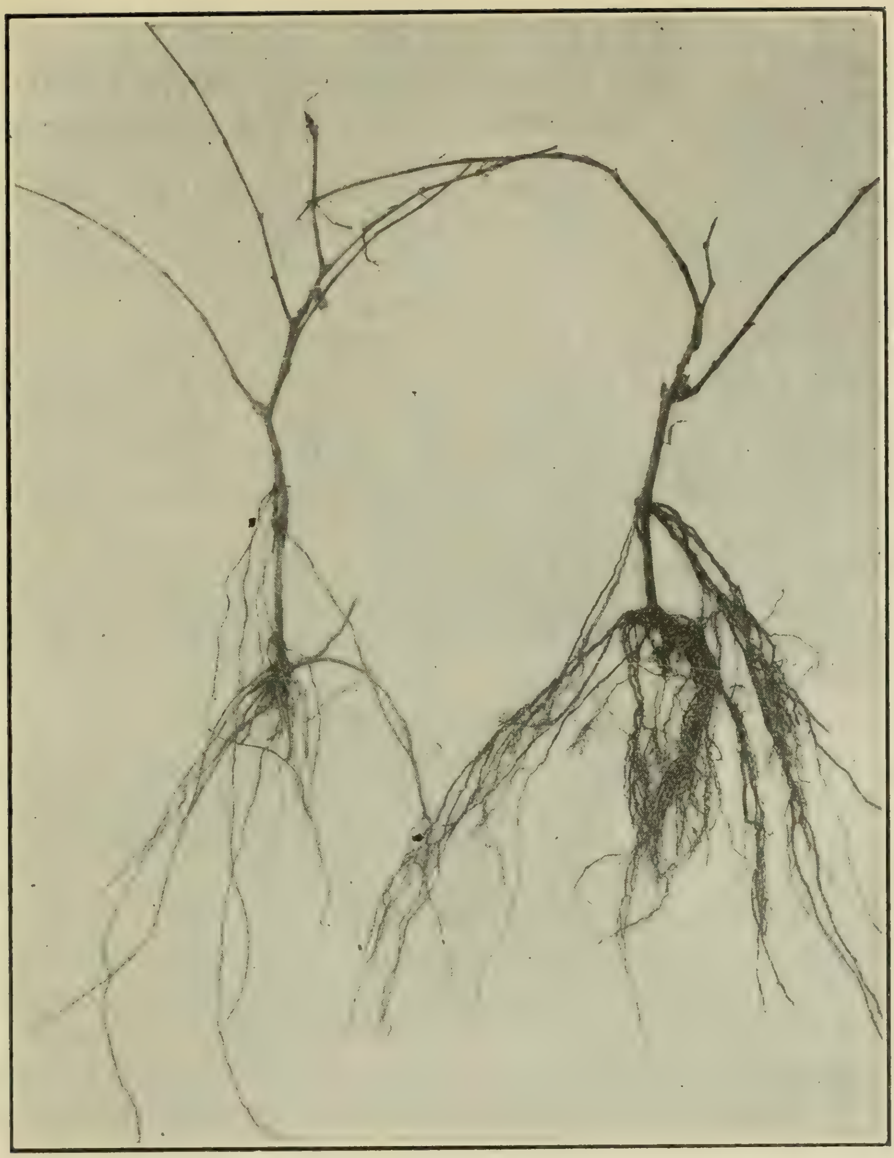


Fig. 4.—Concord vines one and two years of age as they are received from the nursery.

cuttings are placed in them only the upper bud projects above the surface. The cuttings are hoed and cultivated frequently during the summer, and by fall the young vines will usually have made a strong growth.

When the young vines have properly matured their wood, about November first, they are plowed out. The vines are then gathered in bundles of convenient size for a man to handle and are taken to storage cellars. Here bundles of vines of different varieties are packed in separate bins. The vines are usually piled in two tiers with the tops out and the roots in. By this method the roots are prevented from drying out, and air is allowed to circulate around the tops thus holding mildew in check. Modern storage cellars are equipped with a proper system of ventilation by means of which the moisture content and temperature of the air can be controlled.

While in the cellars the vines are graded as No. 1's, No. 2's and culls. Any two-year-old vines on hand are also divided into these three grades. Cuttings which have made a strong, well-balanced growth of root and top are classed as No. 1, year-old vines. A No. 2, year old vine has made a somewhat weaker growth or the top may be a little over-developed compared to the root system.

Culls are those vines which do not fall in either grade, and are usually discarded.

Those vines which are not sold in the spring are replanted and sold the following year as two-year-olds. In a few cases vines of the standard varieties, and some of the weaker-growing kinds are allowed to grow in the nursery for two years before being sold.

From this description the grower will readily see that for commercial plantings first-class one-year-old vines are to be preferred to first-class two-year-olds. Most large growers realize this, but to the small, inexperienced planters the larger, two-year-old vines look more promising.

Very frequently the grower does not place enough importance on the selection of first-class stock. To many the lower price of the poorer grade appeals strongly. Nevertheless in purchasing vines it must be borne in mind that the young vines are the foundation stock upon which the vineyard is to be built; and, if poor vines are planted, the vineyard will be handicapped right from the start.

Immediately on receiving the vines from a nursery the bundles should be opened, the vines spread out, and heeled in in some sheltered spot. The earth should be well mounded up to the vines and care taken not to mix the varieties.

PLANTING THE VINE

Vines may be planted from as soon as the soil is in good tilth in the spring until about the first of June. The earlier the vines are set the better, because this enables them to become well established in the soil before the heat of the summer comes on.

The young vines must be pruned before planting. If the vine has several canes, all but one should be removed and this one should be shortened to two buds. This pruning makes the vine less liable to dry out before rooting, and forces the growth from the lower buds which produce more vigorous shoots. The roots should also be thinned and cut back to about nine inches. Long roots are of no advantage to the young vine, because they are not the feeding roots, and are of no use until they develop feeding roots.

Previous to planting, the vineyard must be staked to show the location of the rows. Needless to say care must be experienced in making these rows straight. The ease of all subsequent vineyard practices depends more or less upon this. Then to facilitate striking a straight furrow in which to set the vines, stakes may be set at frequent intervals along these rows. As deep a furrow as possible is made the first time and then by returning in the same furrow it can be made about ten to twelve inches deep, which is sufficient for the vines. Where the soil is shallow, it may be necessary to dig all holes instead of using the plow except for marking.

As soon as the furrow is made, planting should be begun, and should follow up the plow all the time. A rod cut to a length equal to the distance apart of the vines in the row may conveniently be used to show the position of the vines. One man usually does the planting, but in case of large plantings two men are often used, and a boy supplies them with vines which have already been pruned.

In planting, the roots of the vine should be spread out carefully, and the ground firmly tramped over them and beyond them to a distance of eighteen inches. The vines must be set so that the two buds left on the cane are just above the ground. If the vines are set deep enough, the roots of the young vines spread out, and the soil well firmed over them, the grower can count on most of his vines taking.

CARE OF THE YOUNG VINEYARD

The only attention the newly set vineyard requires during the first season is thorough cultivation. This may be given most economically in conjunction with a companion crop or intercrop requiring clean cultivation such as early potatoes, sweet corn, tomatoes, etc. In Michigan, corn is used more than any other companion crop, though some growers may object to it on account of shading the vines and preventing good air circulation. Inter-crops should be used during the first season only.

If the vines make good growth in their first year, it is well to set the trellis in the fall so that the vines may be trained up to the wires the following spring. If growth has been poor, trellising may be delayed a year, in which case the vines should be pruned back uniformly to one cane of two or three buds. Many growers practise pruning back in this way at the end of the first season's growth, irrespective of the amount of growth the vines have made. However, experimental work has shown that, where good growth has been made, there is nothing gained by delaying trellising. In fact, fruiting is delayed and without any corresponding benefit to the young vine. Train those vines which have made sufficient growth to the top wire. With those of lesser vigor some may permit of training to the lower wire, while others will need to be cut back to a single cane of two or three buds as already indicated.

In training the young canes to the wires, only one cane of course, the most vigorous and desirable, should be left to each plant. This should be cut off just above the upper or lower wire as the case may be. The canes should be straightened out and tied tightly to the wire so as to keep the canes taut thus developing good straight trunks. With weak vines which had to be cut back to 2-3 buds, all but one of the new shoots which start to grow, should be removed early and this shoot should be tied to the trellis as soon as it is long enough.

During the second season's growth it is advisable to remove all suckers and secondary shoots which may be produced below the first wire. This will encourage growth on the upper part of the vine. If this is done carefully the grower will rarely be troubled with suckers in later years. After the third season's growth the vine is pruned to suit the system of training which is to be followed; and from then on it is treated as a mature vine. In the above discussion it has been assumed that the Kniffen system of training will be followed.

Mulching.—The mulching of young vines late in the fall with straw or strawy manure is a practice to be recommended. The mulch not only serves as a protection but, when plowed under in the spring, improves the physical condition of the soil.

TRELLISING

Posts and Bracing

Well cured cedar posts are preferred by most growers, though the creosoted post is coming into favour. The creosoted post is longer lived than the cedar and in consequence somewhat lighter posts may be used. If cedar posts are used the end posts should be at least five inches in diameter and eight and one-half feet long, the intermediate posts three inches in diameter and six and one-half to seven feet long. The posts should be set approximately thirty feet apart in the row, depending on the planting distance of the vines, and, in the case of the intermediate posts, should extend into the ground two and one-half to three feet.

There are many methods of setting and supporting the end posts. In any case the end post must be set four to four and a half feet deep to enable it to withstand heaving, and to support the weight of the vines and fruit. Perhaps the oldest method is that of bracing the end post with a rail or scantling from another post set about eight feet away in the row. The brace should reach from a point about a foot above the ground on the second post to within eighteen inches of the top of the end post. To complete the bracing a guy must be passed from about six inches of the top of the second post to a short distance from the ground on the end post. This method is one of the strongest and most satisfactory. The high cost of scantling for braces and also the cost of an extra post are the factors which are against its more general use.

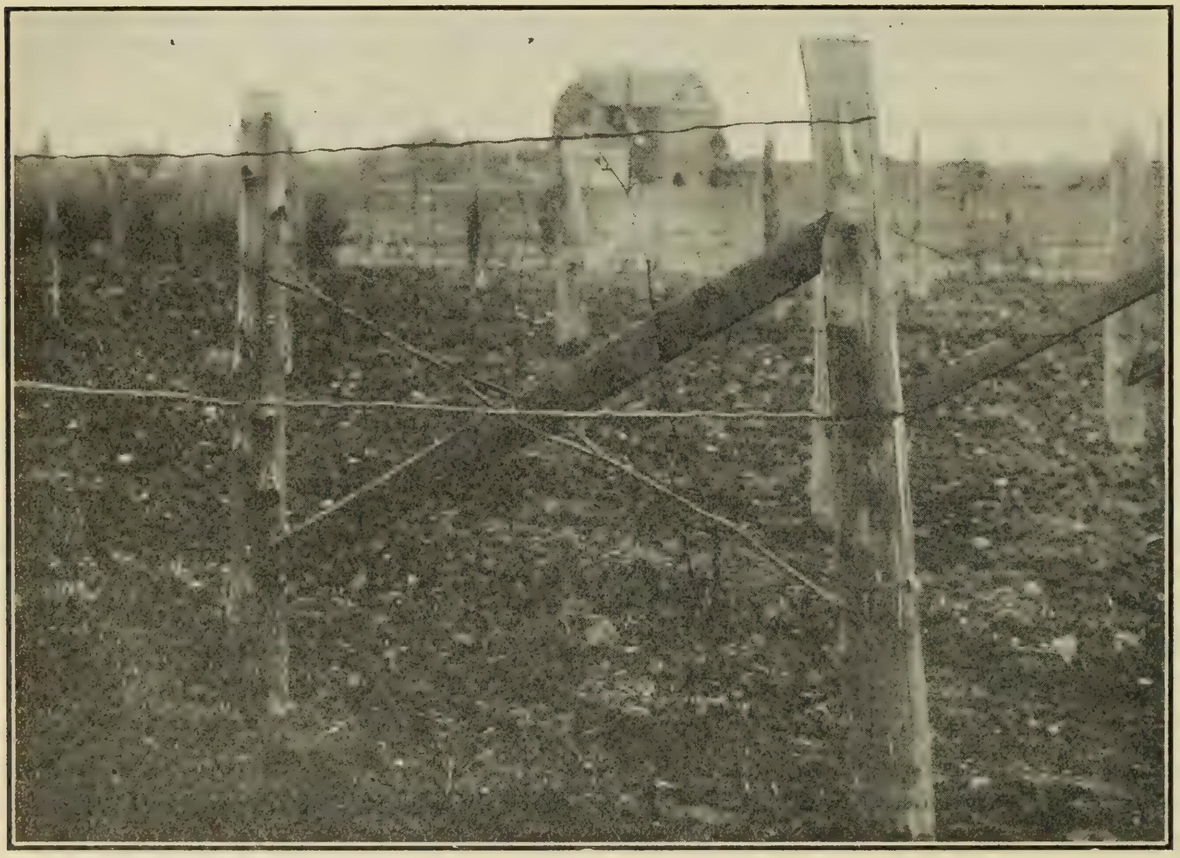


Fig. 5.—The method of bracing the end posts in the vineyard at the Vineland Experiment Station.

Another method which is being much used because of its low cost is that of guying the end post. The post is set in a hole at a slight angle. Some large, heavy stones may be placed in the bottom and the rest of the hole filled and packed with soil. The post is then guyed with a strong galvanized wire, one end of which is fastened to the post one foot from the top and the other end to a stone, or short post buried three and a half to four feet in the soil and from four to five feet from the post, which is as near to the post as it is possible to get without decreasing its purchase. Besides the small original cost of setting these guys they furnish strong support to the posts while they last. The wires however are a nuisance in cultivating. The implements will not only often hitch into them, sometimes breaking them off; but the wires are bound to rust and break, and it is hard and expensive to replace them. Another point is that the head rows of the vineyard are much more difficult to keep clean when this method of supporting the end posts is used, than when they are braced or set in cement.

Still another method which is being used to some extent is that of setting the end posts in cement. The holes are made as deep as for the other methods, but the bottoms are cut out to twice the usual diameter. This is done to give the cement and post more of a purchase on the surrounding soil. Notches are cut with an axe on each side of the butt end of the post to enable the cement to hold the post firmly when it sets. When the cement is mixed with sand and rubble in the proportion of five sand and rubble to one of cement, it is found that one bag will do about four holes. About two feet of this concrete in the bottom of the hole will hold the post. To prevent the post rotting, the hole may be filled slightly above the surface of the soil, With the end posts set in concrete the trellises present a very neat appearance; they are strong, and it is easy to keep the dead rows of the vineyard clean. In certain clay loam, and clay soils, these posts will heave so badly in the spring that it is only a few years before they are out of the ground entirely.

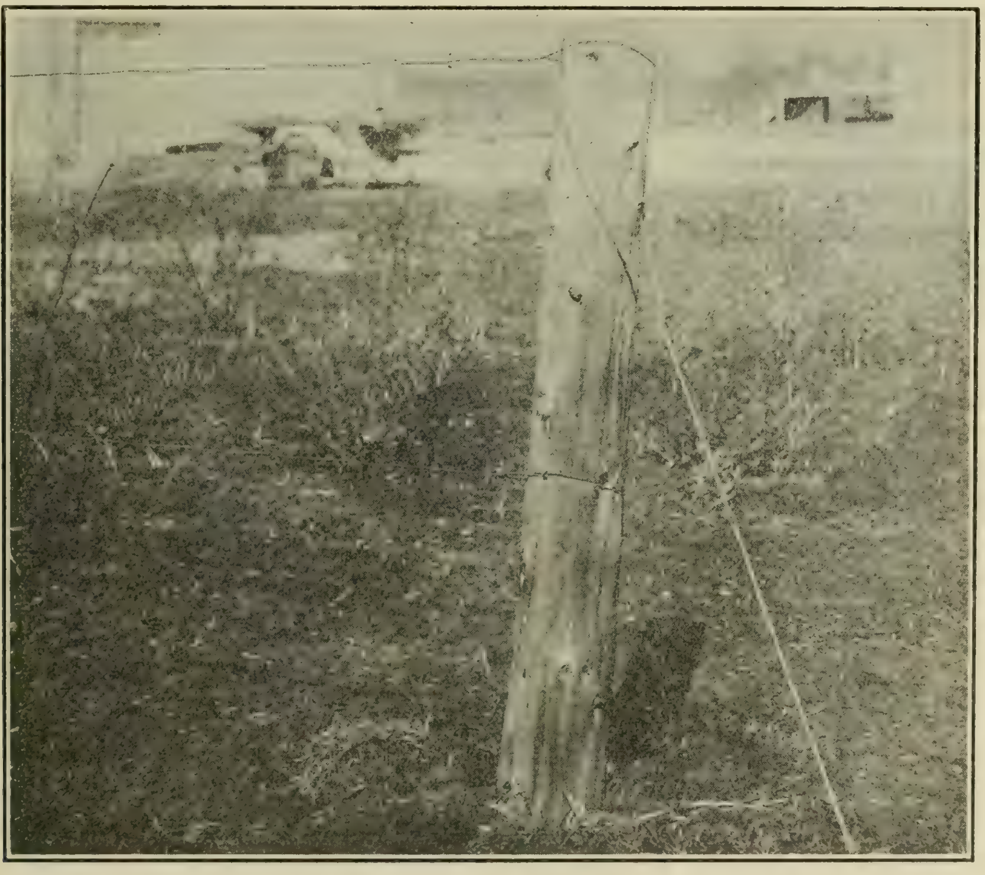


Fig. 6.—Post anchored to rocks buried several feet in the ground. This is by many considered the best method of bracing.

WIRING

No. 9 galvanized wire is the proper size to use. A lighter wire gives way too soon. Two wires are usually sufficient to train the vine on. The first one is put thirty inches above the ground and the second twenty-four to thirty inches above the first. In some special cases three and even four wires are used. If the trellis is made with the three wires they should be spaced twenty inches apart up the post. This would bring the third wire to a height of five feet above the ground.

Wiring a vine-yard may be done very quickly. Quarter inch holes are bored in the end posts, the same direction as the wire is to be strung, and at the distances the wires are to be above the ground. When the wire is stretched along the row both ends of it are passed through these holes in each end post and made fast to the wire tightener. While a proper wire tightener with block and pulley is the most satisfactory, yet many simple devices may be used for tightening the wire. One of the most common is a block of hard wood one and a half by one and a half inches square and eight or nine inches long with a quarter inch hole bored through the middle of it. The wire is passed through the hole in the stick and made fast; then it is tightened by turning the block with a monkey wrench. The tautness of the wire, together with its shape, keeps the block in place.

In another method a small iron reel is fastened to the end post directly opposite the hole bored for the wire. When the wire is strung it is passed through the hole, made fast to the axle of the reel, and tightened by turning the reel with a special detachable handle. A small "dog" attached to the outside of the reel prevents it from unwinding.

When stapling the wires to the posts space should be left to allow the free passage of the wire when it is slackened in the fall and tightened in the spring. Unless the wire is regularly slackened in the fall, it and the posts will be subjected to an undue strain when the already taut wire contracts with the cold weather. This strain will in time either loosen the posts or break the wire.

NUMBER OF FEET TO THE POUND OF DIFFERENT SIZED WIRE

No. 9—Feet to the pound	17.95
No. 10— " "	22.33
No. 11— " "	27.34
No. 12— " "	34.29

PRUNING AND TRAINING

TRAINING THE VINE

Different grape growing sections often have preferences as to systems of training. In the Niagara district many systems may be found such as Fan Arm or Horizontal Arm. four cane Kniffen, Improved Kniffen, and "go as you please." There seems to be a growing sentiment in favour of the four-cane or ordinary Kniffen, though possibly no one system has any distinct advantage over another. The main advantage of any system is that it *is a system*, with consequent uniformity of work and appearance, and simplified handling in vineyard operations, particularly pruning.

The Kniffen, Improved Kniffen and Fan systems are shown in accompanying illustrations and need no further description. The Kniffen and the Fan are the most commonly used systems in the Niagara District.

PRUNING

The training and pruning of the young vine have already been discussed in the section dealing with The Care of the Young Vineyard. The present discussion concerns the mature bearing vine.

Time of Pruning.—Pruning may be done any time after the leaves have fallen from the vines until the vines begin to "bleed" in the spring. The main thing is that the vines be thoroughly dormant. The usual practice throughout the Province is to do most of the pruning during the months of January, February and March. Any time during these months will be quite satisfactory except on very cold days, when the vines are very brittle from heavy freezing, and such other days as it is impossible for a man to work conveniently and to good advantage out-of-doors. The usual plan in the Niagara District is to prune the grapes first during the winter months, leaving the peaches till the warmer days of early spring.

Number of Buds per Vine.—The objects of pruning are to restrict the growth of the vine sufficiently to enable it to produce the maximum quantity and quality of fruit year after year without impairing the vigor of the vine; to economize in space; and to facilitate vineyard operations such as cultivation, spraying and harvesting.

The amount of wood or the number of buds to be left per vine will vary with the variety and the vigor of the individual vine. Generally speaking, the greater the vigor, the more buds can safely be left. In other words individual grape vines should be pruned in accordance with their ability to produce fruit. Again, this ability may vary from season to season even with individual vines as their growth will vary with seasonal weather conditions, varying soil fertility, amount of previous crop, etc.

It is evident then that no hard and fast rule can be laid down stating that so many buds, say forty, should be left for all varieties under all conditions. Rather, individual growers will have to determine the optimum number for their particular conditions varying this number to some extent with occasional vines which are above or below normal in vigor. A general rule of twenty-eight to forty buds per vine may be laid down.

In addition to leaving the four regular fruiting canes it is often advisable to leave additional short two-bud canes from which new vigorous canes close to the main trunk may be secured the following season. The function of such "spurs" is of course to provide a renewal of fruiting wood close to the trunk, and it is therefore unnecessary to leave such spurs where the arms are already short.

Date of maturity of the fruit is influenced by size of crop. This is an important point in the Niagara District, especially for those growers whose vineyards are naturally inclined to be late in maturing. Vineyards close to the lake for example, would fall in this class. In a general way it may stand that the greater the crop the later the maturity. It is obvious, therefore, that the grower who habitually suffers from too late maturity should practise more severe pruning. In his case the optimum number of buds is determined by date of maturity rather than by the quantity of fruit that the vine can support year after year without noticeable impairment of vigor.

Some further light on the optimum number of buds per cane may be secured from the following figures obtained through the courtesy of the Horticultural Extension Department of the College of Agriculture, Ithaca, N.Y. The figures are for the Concord variety trained on the four-cane Kniffen system. One bud per cane therefore would mean four for the vine as a whole.

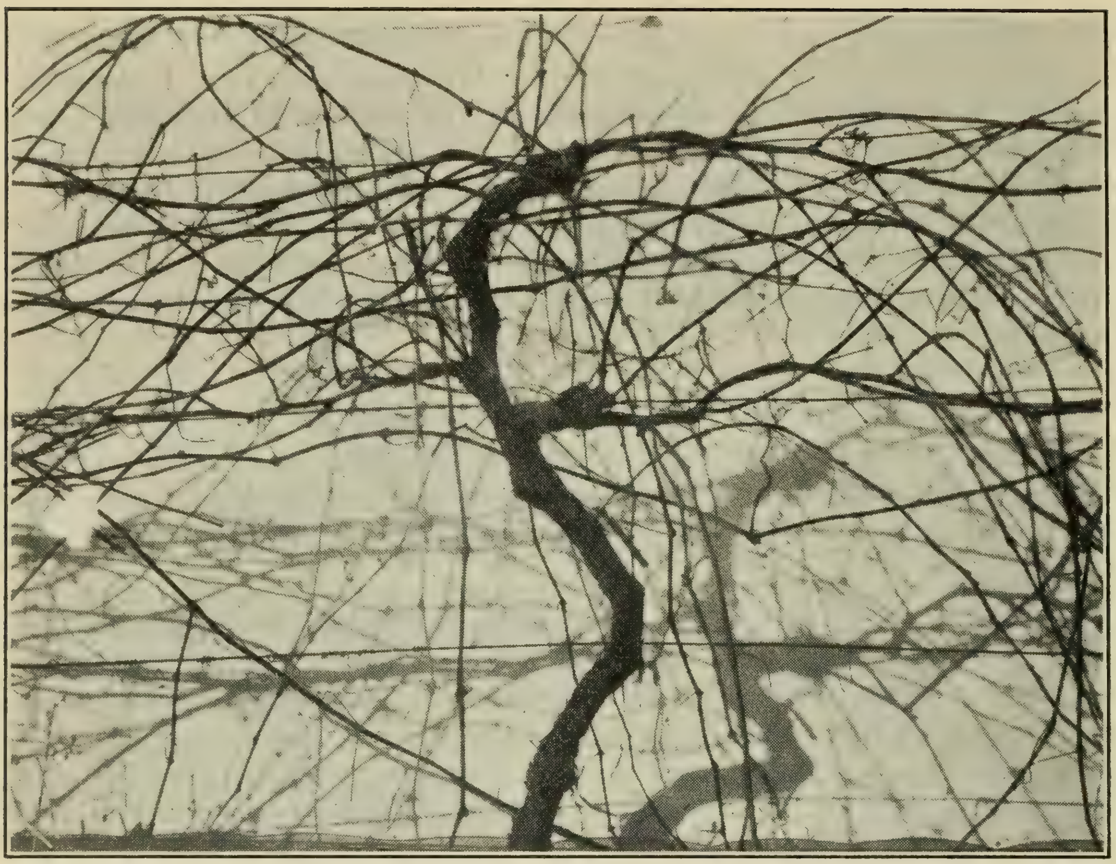


Fig. 7.—Unpruned grapevine, Kniffen system.

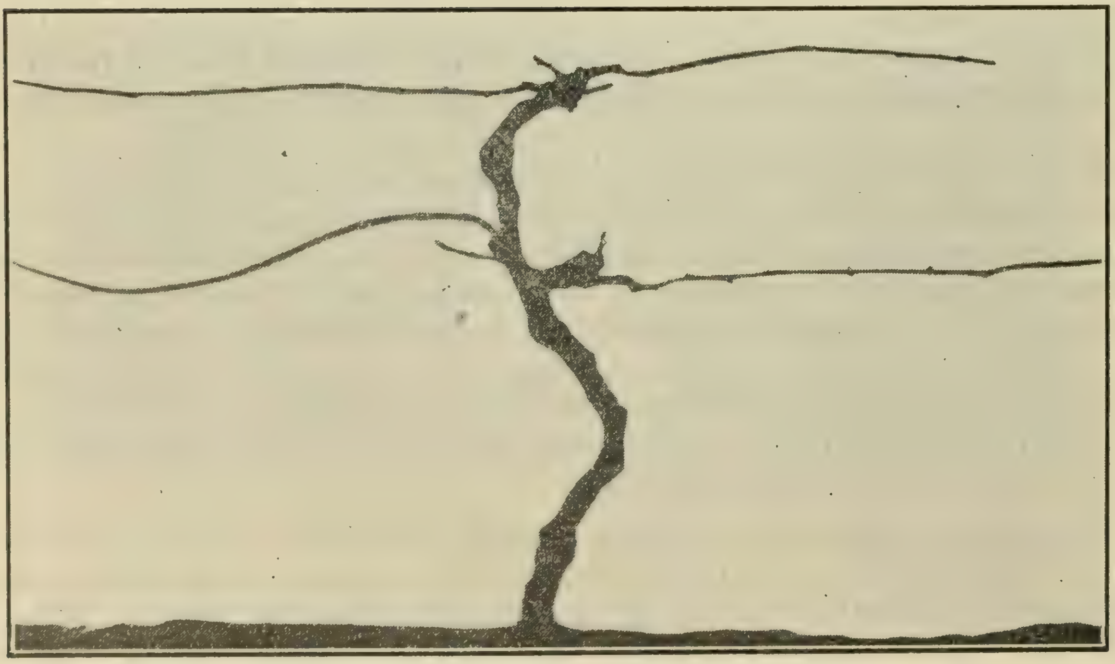


Fig. 8.—The same vine as in Fig. 7, pruned.

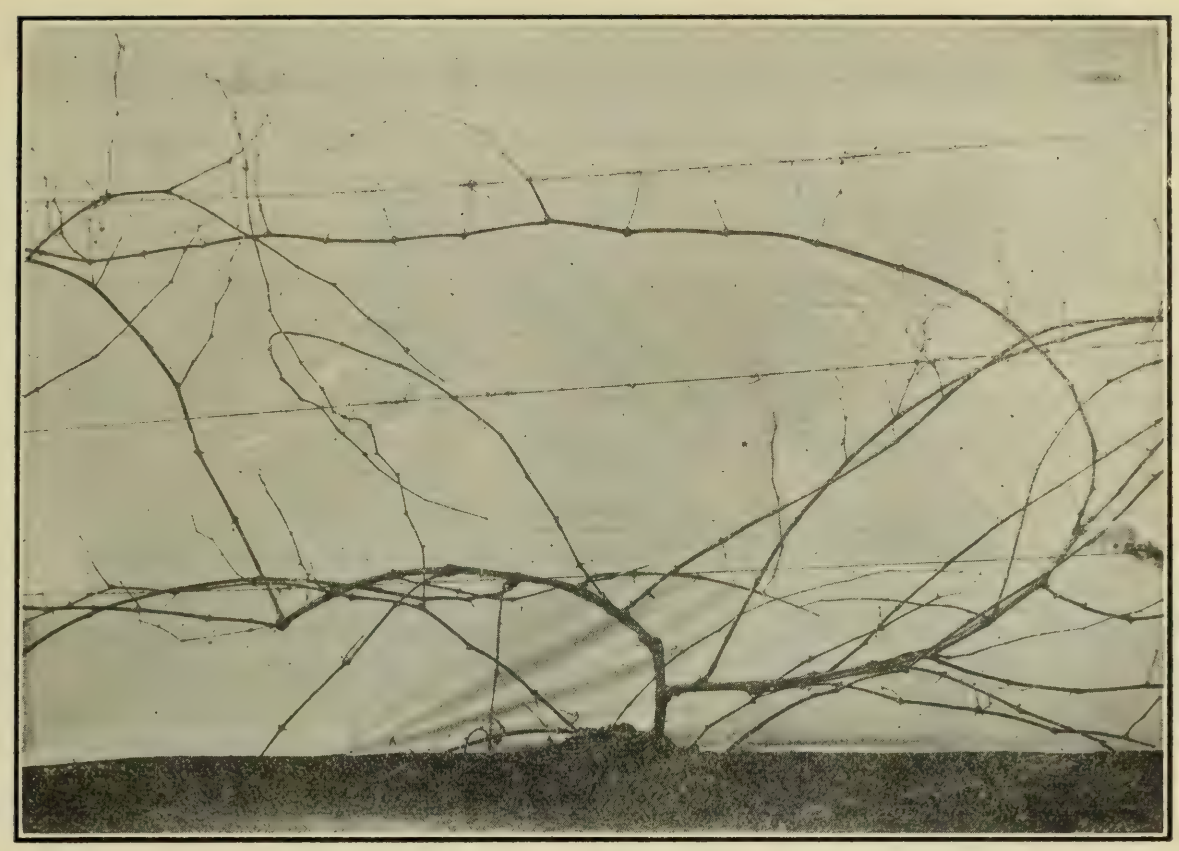


Fig. 9.—A vine that looked difficult to prune.

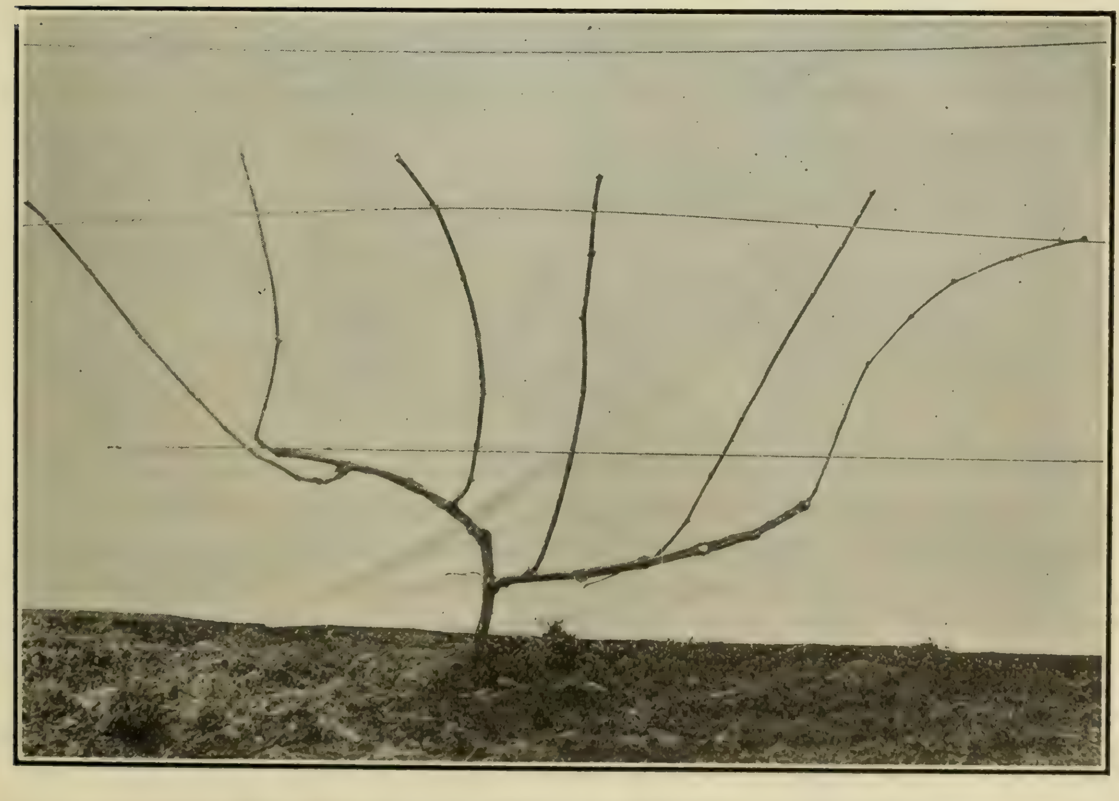


Fig. 10.—The same vine as in Fig. 9, pruned and tied.

TABLE IX—NUMBER OF BUDS DESIRABLE PER CANE

Number of Buds	Ounces of Fruit Per Bud
1	3.4
2	3.2
3	3.5
4	4.8
5	5.4
6	5.5
7	5.8
8	7.0
9	7.8
10	6.3
11	6.2

Thus it will be seen that for this variety and for the vigor of the particular vines used in the experiment, heaviest fruiting occurred at about nine buds per cane or thirty-six per vine. From ten buds on there was a decline in *average yield per bud*, though the total yield per cane and per vine fell little if at all below the nine bud canes. Nevertheless there must have been a falling off in size of bunches, and probably also delayed maturity with consequent lowered quality.

Spur System vs. Long Arm Pruning.—The question often arises as to whether it is more desirable to leave many canes with comparatively few buds each, or fewer canes with relatively more buds per cane. The consensus of opinion is now in favour of the latter method. There is sound evidence to back up this opinion as will be seen from a study of the following figures also secured through the courtesy of the Horticultural Extension Dept. at Ithaca, N.Y.

TABLE X—FRUITFULNESS OF INDIVIDUAL BUDS ON THE CONCORD GRAPE

Bud No.	Ounces of Fruit
1	1.2
2	3.2
3	5.2
4	7.4
5	7.9
6	7.9
7	8.0
8	9.2
9	9.3
10	8.5
11	7.3

The buds are numbered 1-11 consecutively beginning at the base of the cane. It will be seen that the first two or three buds on the cane are relatively unproductive and that the most productive part of the cane is from the fourth to the ninth or tenth bud. Of course with vines of greater or less vigor than those used in the experiment the relative fruitfulness of the outer buds would vary accordingly, up or down from the figures given.

The evidence presented in Table X certainly indicates the desirability of relatively few canes, such as the four cane Kniffen, of eight to ten buds each (32 to 40 per vine) rather than a greater number of canes with proportionately fewer buds per cane. In the latter case there will, of course, be a higher proportion of the relatively unproductive buds, numbers one to three.

Relation of Cane Diameter to Fruitfulness.—The so-called "bull" canes are generally considered unproductive and undesirable. The correctness of these conclusions is indicated in experimental data obtained by N. L. Partridge, of Michigan. These data show that the medium or pencil-size canes of approximately one-quarter inch diameter are the most fruitful. An increase or decrease in size from the quarter-inch is accompanied by decreased fruitfulness in both cases, the amount of decrease being roughly proportional to the deviation from the optimum size—one-quarter inch. Where canes of the right diameter are unobtainable, those slightly above the quarter-inch are to be preferred to those falling below this diameter. In addition, canes of moderate length between joints are to be preferred to short-jointed canes.

Influence of Overbearing.—The following paragraphs and the two accompanying illustrations are from Michigan Special Bulletin 141, by N. L. Partridge:

> "The larger the crop produced by a vine, the smaller the amount of shoot-growth produced during that season. Seasonal conditions sometimes obscure this effect. A vine that is permitted to overbear makes a comparatively weak growth during that season, with the result that the amount of weight of the canes to be removed by pruning the following winter is usually less than the amount obtained the winter preceding the crop. The vine is weakened by overbearing. A vine that is not permitted to bear a full crop usually produces a greater weight of cane-growth than it did the preceding year. The vine is strengthened by overpruning. However, overpruning is not the best method to use in strengthening weak vines because it is too expensive—the following crop being too much reduced. Soil treatments are a better means for securing the same result.
>
> "Under a given set of environmental conditions, maturity of fruit and cane depends on the ratio of effective leaf surface to pounds of fruit on the vine. A vine that is overbearing will not mature fruit and canes as well as it would if it were carrying a smaller crop. The use of certain fertilizers increases leaf area, so these vines are able to mature their fruit better than are similar unfertilized vines. Neglected vines that are poorly cultivated or poorly sprayed do not have as large an effective leaf area as the well-cared-for vine and will not be able to mature as large a crop as the vine receiving better treatment. The severity of pruning should be varied to meet the conditions which are to be expected during the following season. If cultivation is to start late and be of a poor quality and spraying is to be neglected, the vines should not be permitted to bear as large a crop as though good cultivation, fertilization and spraying were contemplated."

Some Varietal Differences in Relation to Bud Number.—As already intimated the optimum number of buds per vine to be kept in pruning will vary to some extent with the variety. For several years an experiment was conducted in the Station vineyard to study varietal differences in this respect. The results of these observations are given herewith.

The optimum number of buds per vine as judged by maturity of fruit, unimpaired vigour of vine, and continuous yield for the six-year period, 1918-23, varied from twenty-eight to forty-eight for the ten varieties under observation. The accompanying table gives the results in brief:

TABLE XI—OPTIMUM NUMBER OF BUDS PER VINE FOR STATION VINEYARD

Variety	No. of Buds
Vergennes	28
Brighton	32
Concord	36
Delaware	36
Diamond	36
Herbert	40
Lindley	40
Niagara	40
Agawam	44
Massosoit	44

Most if not all of the above varieties will give as good yields and sometimes higher where the number of buds exceeds by four or more the optimum number noted. However, time and evenness of maturity must be considered. Also it follows that where an increase in number of buds (with its increased number of bunches) does not give a proportionate increase in yield, the berries and bunches on the higher bud-number vines must be of inferior size. Nothing, therefore, has been gained by increasing the bud number, and much may be lost by delayed maturity, etc.

The twenty-eight buds noted for Vergennes may seem low. Vergennes is a notorious overbearer, and if insufficiently pruned, the fruit will fail to colour or mature properly and the vines will fall away in vigour.

With Concord forty buds may be left on vines of normal vigour, rather than the thirty-six noted, provided that the particular vineyard does not habitually suffer from late maturity due to location or some other factor. The same reasoning holds for many other varieties, including Niagara and Herbert. Nevertheless, as already indicated, improper maturity is so often a factor in the Niagara district as a whole, that the grower should err, if at all, on the side of too few rather than too many buds.

Delaware canes are short-jointed. With this variety number of buds should not be estimated by length of cane alone but by frequent count, otherwise far too many buds will be left by the average pruner.

The Rogers' hybrids, such as Agawam and Massosoit, are very vigorous growers and, apart from other considerations, a relatively large number of buds must be left or growth will be too rampant and of the "bull cane" type. Also Lindley, Agawam and Massosoit normally mature early so that this factor does not need the same consideration. Herbert is later in season and does require consideration.

Directions for Pruning a Vine.—The discussion on training and pruning the grape may best be closed by a further quotation from Michigan Special Bulletin No. 14, as follows:

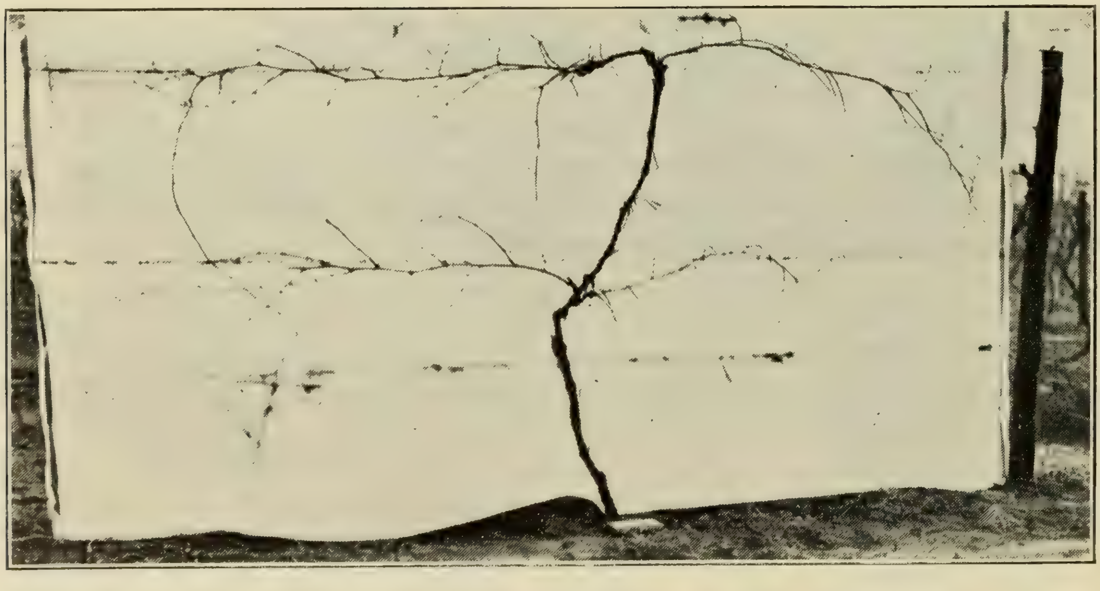


Fig. 11.—A vine weakened by overbearing, due to underpruning. Compare with Fig. 12. (courtesy Dept. of Hort., Michigan State College of Agr.)

"The annual pruning for a vine of medium vigour, that is, a vine yielding from two to two and a half pounds of prunings, should be about as follows: First, select four fruiting canes as nearly a quarter of an inch in diameter as possible, with the joint between the fifth and sixth buds between five and eight inches in length. These canes are to be trained in either direction along the two wires and should originate from the trunk or as near the base of the arms or branches as this type of wood may be found. Second, if the fruiting cane does not originate within six or eight inches of the trunk and if there is another cane growing closer to the trunk than the one retained for fruiting, this cane may be cut back to a one or two-bud spur to provide a renewal for next year's fruiting. Third, cut back the canes left for fruiting so that the total number of buds on the vine is between thirty-five and forty, balancing the distribution of the buds so that the larger number are left on the larger canes. Fourth, remove all other wood. Pruning other vines should be similar except that the buds left should balance the fruiting capacities of the particular vine pruned.

"Most grape-pruners do not devote sufficient time to the vines they trim. The grower will be repaid at the harvest for the time that he spends in choosing the best wood for fruiting and accurately balancing the production of vine and cane to its capacity."

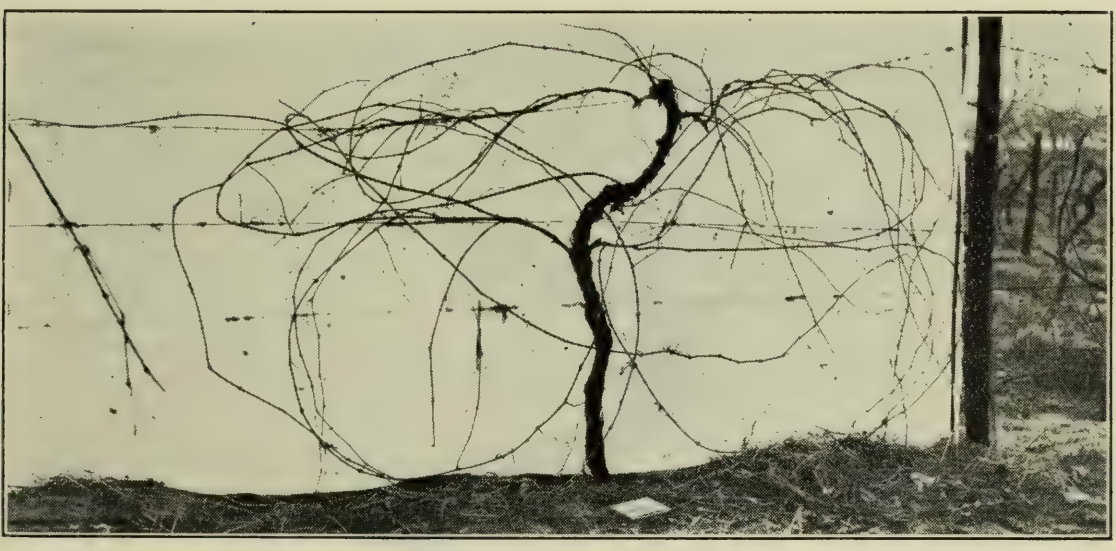


Fig. 12.—A vine in good condition as a result of balanced pruning. Compare with Fig. 11. (courtesy Dept. of Hort., Michigan State College of Agr.)

RENEWING OLD VINES

It is sometimes necessary to renew old vines where the trunk has become crooked and bent and has perhaps deteriorated from disease. If the root is healthy such renewal can usually be effected by bringing a new lateral from near the ground. The old trunk may be removed at once or may be left to fruit for one or two seasons until the new cane is fully ready to take its place.

TYING THE VINE

Following the dormant pruning and the tightening of the trellis wires, tying is the next vineyard operation. Tying should not be done when the canes are frozen as they are then quite brittle and easily broken. Nor can tying be delayed until after growth starts because of the danger of rubbing off the new growth.

Grape twine and fine wire are both used for tying, though most growers prefer the twine. The twine is the better material of the two, though when carefully used wire gives quite satisfactory results. Wire cannot be used to secure the trunk and main arms of the vine to the trellis because of the danger of girdling and killing the vines.

The trunk should be tied tightly to both wires in an upright, straight manner. Sagging, crooked trunks interfere with many vineyard operations. Before tying the canes (Kniffen system) it is a common practice to give the cane one or two twists around the wire. This secures the vine more firmly to the trellis than merely stretching the cane along the wire. However, such wrapped canes materially increase the difficulty of pruning the following season. In either case each cane should be tied twice, once at the tip, where a tight knot should be made, and once near the base, in this case a loose knot so that normal cane growth, without binding or girdling, may be made.

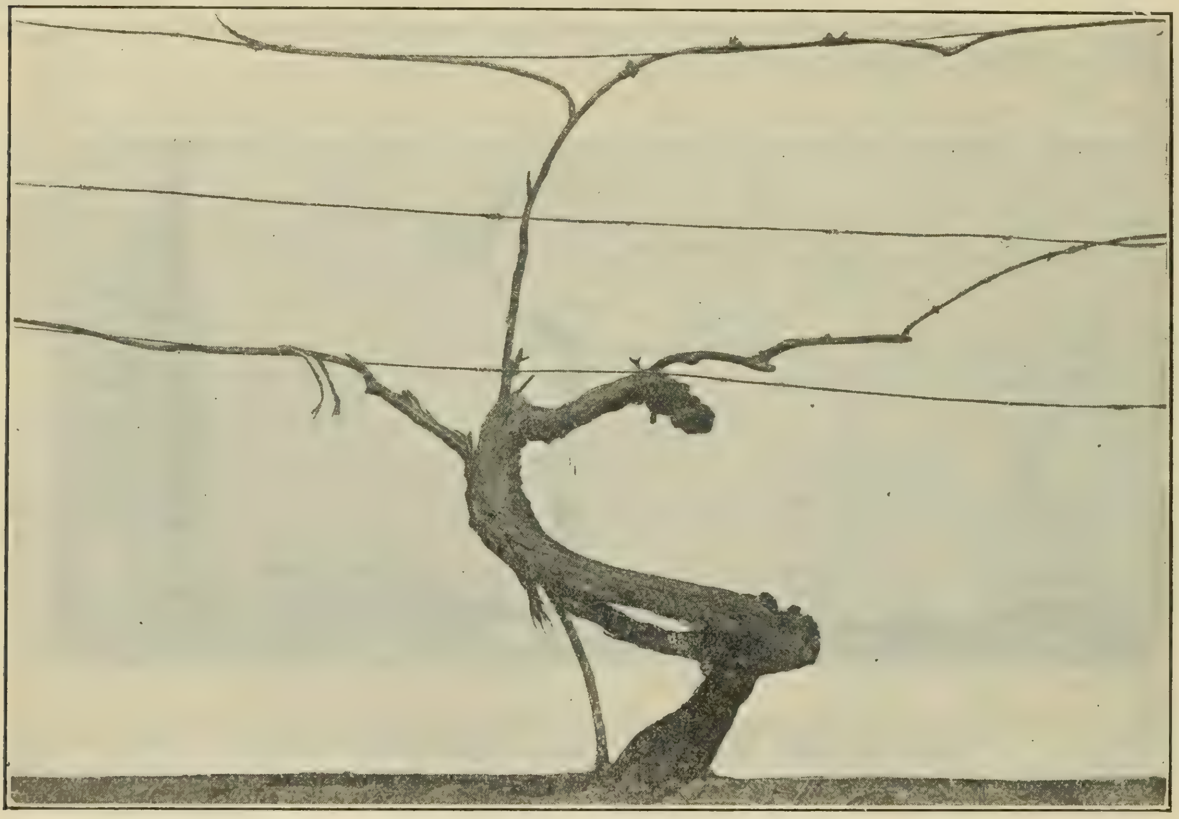


Fig. 13.—Renewing an old vine. Note the new cane from the base of the old trunk.

When tying with grape twine it is advisable to give the cord a couple of turns around the wire, knot it and then tie the cane securely to the wire. This method prevents any slipping of the cord along the wire, and, at the base of the cane, permits of a secure though loose tie, thus allowing for cane expansion.

It is false economy to hurry over the tying of the vines or to use material for tying which is not sufficiently strong or durable. This always results in much troublesome re-tying and often injured arms.

DISBUDDING

Disbudding is practised on young vines which have not yet formed a stem in order to concentrate the growth into one or two shoots. The following year the stronger of these shoots will be selected to form the stem of the vine. In case of mature vines, disbudding consists in rubbing off all the buds on the lower part of the vine and on the trunk which are not needed for renewal purposes. This is done in order to concentrate the growth in the shoots above and prevent the production of shoots down below the first wire where they would eventually have to be cut off. These buds or young shoots should not be removed until they are from three to four inches long. Since there are many dormant and adventitious buds on the trunks of the vines, any attempt to remove the buds too early would force them out and necessitate going over the vineyard too often.

SUCKERING

Suckering is the removal of all the shoots which appear on the trunk of the vine at or below the surface of the soil. These suckers bear little or no fruit, and hence grow vigorously, appropriating food materials which should go to the vine. A great deal of time and expense will be saved if suckering is done carefully during the first four or five years of the vine's growth. After the fifth year very few suckers will be produced from vines which have been carefully suckered when they were young. Vines on which the work has been carelessly done will always produce an abundant growth of these underground shoots every year. Suckering should be done early in the summer before the shoots have become hard and woody, not only because of the fact that they diminish the vigour of the vine, but also because, if the shoots are left for the whole season, or for any length of time, they promote the production of dormant buds below the surface of the ground. These old suckers are more difficult to remove than are the young shoots, and, if imperfectly removed the remaining part becomes an underground spur which will be a perennial source of trouble.

SUMMER PRUNING

The removal of two or more feet from the end of growing shoots during the month of August is a common practice in the Niagara district. It is done to admit light to the fruit, thus increasing its colour, and also to control mildew by permitting a better circulation of air through the vine. Since this topping is done towards the latter part of the summer, a great number of leaves are removed, which is very weakening to the vine. In the case of very vigorous vines this may not be serious, but, if severe topping is practised annually it is bound to weaken even the strongest vines.

In certain seasons when excessive growth is produced because of a prolonged rainy season, it may become necessary to resort to topping to admit sufficient light to colour the fruit or to check the spread of mildew; but never in a normal season. At least seven or eight leaves should be left beyond the fruit when topping in August. The grower should, however, be able to maintain the equilibrium of his vine by increasing or diminishing the amount of fruiting wood left when pruning without having to resort to this weakening practice of topping.

VINEYARD SOIL MANAGEMENT

Cultivation

Frequent and thorough cultivation throughout the growing season is absolutely necessary for the best growth of the vines and the production of the crop in normal seasons. The first operation in the spring, as soon as the soil is dry enough to work, is to plow away from the vines. For this purpose a gang plow, which does the work quicker and more evenly than a single plow, is preferable. A furrow three inches deep is sufficient to turn over the surface soil and still not deep enough to disturb the surface roots of the vine. It is very important that roots of well-established vines should not be torn up or carelessly exposed by deep plowing. In some cases where the soil is friable and there is no cover crop to plow under, the disc may be used instead of the plow to loosen the soil in the spring. Many growers prefer this method. The grape hoe and hand hoe should now be used to work the soil away from the vines. Subsequent cultivation at least every two weeks during the summer should be given the soil with the disc or spring-tooth harrow. Especial care should be taken to cultivate in seasons of drought and before the soil has become caked and crusted after heavy rains.

All cultivation should be stopped by the end of July at the very latest to give the vines a chance to ripen their wood and fruit before freezing. In backward seasons it would be most advisable to discontinue cultivation at least two weeks earlier than this date. Fall plowing up to the vines may be done at this time, or preferably later, after the crop is off. The disadvantages of early fall plowing are: Some fruit may be torn from the vines by the plow or horses; the soil is left in too rough a condition for the pickers to walk and work quickly along the rows and for the wagon gathering the fruit to be driven over easily.

COVER CROPS

Cover crops have not been generally used in the vineyards of our grape sections. Possibly there has not been the same need for them under our soil conditions as there is under lighter soil conditions of some grape regions. A large percentage of our plantings have been made on mountain wash and black clay loam soils which are rich in humus. Nevertheless there are many cases, and there will be increasingly more, where the use of a cover crop will solve the very problem which is perhaps puzzling the grower.

The functions of cover crops are: To check growth in the full, thus giving the vine time to properly mature its wood; to utilize nitrates available in the soil after the vine has ceased growth, and prevent their leaching; to add nitrogen to the soil, when a leguminous plant is sued; to hold the snow and thus prevent deep freezing; and, of great importance, to maintain or improve the humus content of the soil. Humus, because of its moisture-holding capacity, may be said to form the basis of soil fertility. It holds the plant foods in solution. The grape is a long-lived plant, and, unless the humus supply is replenished, most grape soils will eventually become deficient in their humus content. Barnyard manure, of course, is one of the best suppliers of humus and should be used whenever it can be economically secured. Where manure is not available in sufficient quantity, cover crops or "green manuring crops" will provide a very acceptable substitute.

Some of the best cover crops to use are: Oats (1¼ bush. per acre), rye (1 bush.), oats and clover (1 bush.–15 lbs.), rye and vetch (1 bush.–12½ lbs.), Japanese millet (3 pecks). Oats and Japanese millet both make a strong growth in the fall and are therefore somewhat objectionable at picking time. On the other hand, both are winter-killed and there is therefore no temptation to delay spring plowing as in the case of rye and the clovers, which make heavy growth in the spring. It is essential that spring plowing be done early, as delayed plowing, while it gives a greater quantity of material to plow under, does harm in other ways such as reducing the nitrate content of the soil, causing drying-out, etc.

The cover crop should be sown as soon as cultivation ceases in mid or late July. When sowing, a space of eighteen to twenty-four inches should be left on either side of the row so as to give a clear space for the pickers to walk in. This will obviate some of the objection to oats and millet with their heavy fall growth. These crops may also be flattened down previous to fruit-picking, with a roller or stone boat.

FERTILIZERS

Barnyard manure and green manuring crops should form the basis of the soil fertilizing programme. These, with proper soil drainage and frequent, thorough cultivation, will furnish all the plant food necessary in many vineyards,—probably most of the vineyards of the Niagara peninsula.

As a general rule the vineyards of this district do not need commercial fertilizers. What they do need, in cases where the crops are decreasing and the wood growth is weak, is better general care—good soil drainage, manure or other humus-forming material, sufficient pruning, and proper cultivation.

On the lighter soils or on other soils where good cultural conditions do not give proper growth and yield, applications of readily available nitrogen, such as nitrate of soda and sulphate of ammonia, may be made at the rate of 200-300 pounds per acre. This application should be made about the time growth is starting in the spring. Nitrogen should be used with caution as the general effect of its use, apart from more vigorous growth, is to delay maturity of fruit and vine. On the average our seasons are inclined to be all too short as it is, so that the danger from injudicious use of nitrogenous fertilizers is obvious. Generally, therefore, their use should be confined to vineyards where good cultural practices are failing to produce satisfactory growth and fruitfulness.

The grapevine is normally late in starting into growth. For this reason it is doubtful whether the same beneficial effects will result from early applications of readily available nitrogen to normally vigorous grapevines as to such tree fruits as peaches and apples. The latter start their growth considerably earlier when the soil is cold and inactive and when plant food is not being liberated in any great quantity.

Barnyard manure is, of course, a carrier of nitrogen, and if manure is available, it will probably supply sufficient of this particular food. Again, however, the danger of promoting late growth and of delaying maturity of vine and fruit must be considered. Too heavy or too frequent application of manure with its slowly available nitrogen must be avoided.

Phosphoric acid and potash seem to be present in most grape soils in sufficient quantity for the needs of the grapevine so that applications are not necessary. In the case of phosphoric acid, however, green manuring crops may greatly benefit from an additional supply. Its value, and also that of nitrogen, can best be determined for any particular vineyard by the grower himself. A few simple trials with adjoining unfertilized plots will determine their value.

RINGING GRAPES

The practice of ringing grapevines is not a commercial one, but is often used by growers who intend entering fruit in competition. Where ringing is properly done, the resulting bunches of fruit will mature earlier than on non-ringed canes, and both bunches and berries will be of larger size. The quality and flavour of the fruit, however, are distinctly lower.

Ringing consists in removing a ring of bark one-third to one-half inch in width, from the fruiting shoot on the trunk side of the affected bunch of grapes.

The result of the ringing is that the upward flow of food materials from the root to the leaves is undisturbed, but the downward flow of elaborated food is checked at the gridle and thus diverted to the bunch of grapes.

Experiments in ringing conducted at Vineland, 1915-17, clearly indicated that ringing may best be done, all things considered, from three to four weeks after the bloom opens or approximately the last ten days of July. If ringing is done earlier than this, the ringed shoots will mostly be broken off by high winds; also, the very early ringing does not appear to bring about a corresponding early maturity. Similarly, ringing in August is too late to affect maturity and size to any appreciable extent.

HARVESTING

The one point in connection with harvesting which really needs stressing is that of proper maturity. Practically all grape-growers join in condemning the Champion grape. This variety colours several days in advance of actual maturity, and this fact, together with the further fact that Champion is an early-season variety, tempts many growers to pick for the early market. It is believed, and no doubt with cause, that the placing of these immature, extremely low-quality grapes on the early market seriously interferes with the later marketing of better quality varieties.

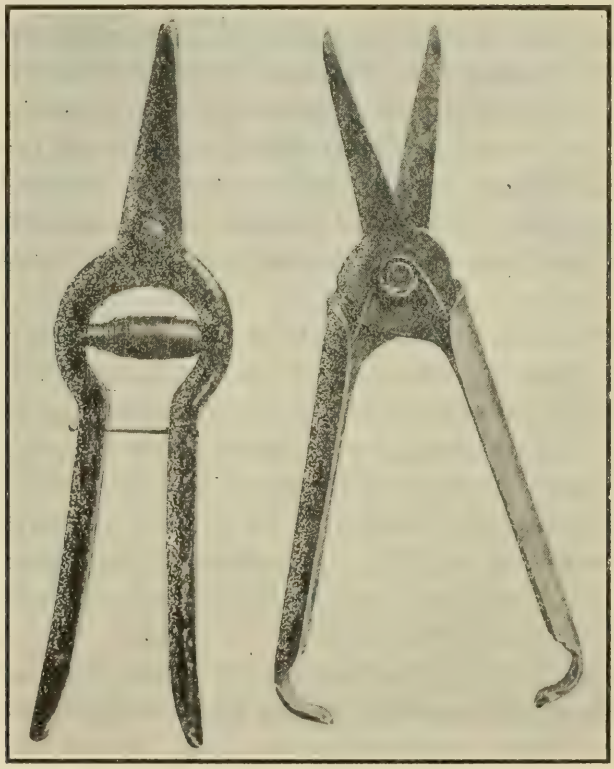


Fig. 14.—Shears commonly used for cutting grapes.

A point often overlooked by grape-growers is that Champion is not unique in its early-colouring propensities. Perhaps few varieties colour so far in advance of maturity as does Champion and few, if any; are so low in quality as that variety. Nevertheless practically all varieties of grapes reach full size and have good colour several days before they are really fully mature. They are not, mature, however, in the sense of full development of sugar content and quality.

The result is that many varieties besides the Champion are harvested before they should be. This is true of the green varieties such as Niagara, as well as of red and blue varieties.

Along with the above fact of general colouring in advance of full and proper sugar development, it should also be noted and emphasized that *there is no appreciable increase in sugar content once the fruit has been cut.* Most kinds of fruit continue to "ripen" after picking, but not the grape. Ripening processes cease immediately the grape is cut. It is obvious, therefore, that grapes should not be cut, even if well coloured, until sugar development is sufficient to ensure good quality. The sense of taste is an easily made and sufficient test for all practical purposes.

GRAPE INSECTS

L. Caesar, Provincial Entomologist

The chief insects attacking grapes in Ontario are the grape leaf-hoppers, rose chafer and grapevine flea-beetle. The grape berry-moth is sometimes troublesome in a few areas.

Grape Leaf-Hoppers

The leaf-hoppers are the most common and, on the whole, the most important insects which injure the grape. There are three species of them, *Eryth-*

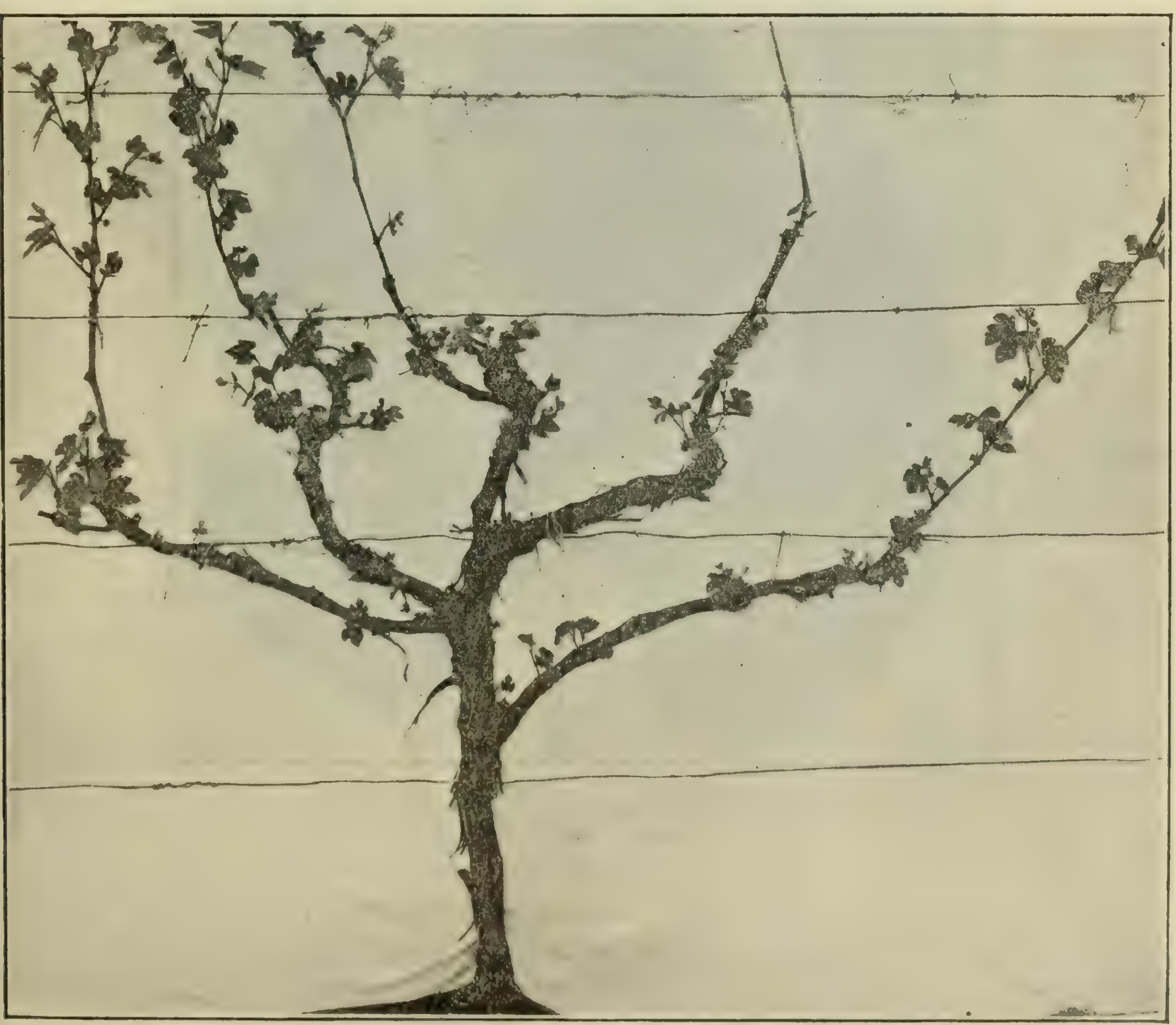


Fig. 15.—The third leaf is showing. This is the time for the first spray.

roneura comes, *E. tricincta*, and *E. vulnerata*. These three species are all about the same size and have the same habits, so that we shall treat them as if they were one species.

The adults are only about one-eighth inch long and have slender bodies which taper gradually toward the anal end. The colour varies greatly but is usually yellowish with red, black, brown or white markings. They are shy insects and if disturbed leap or fly away quickly.

The nymphs or young are paler than the adults, being usually cream colour. They have the same general shape as the full-grown insects but lack wings and, of course, are smaller. Both nymphs and adults live on the under surface of the leaves and feed there.

Injury.—The injury is caused by the adults and nymphs inserting their fine, sharp, needle-like mouth-parts into the tissues of the leaves and extracting the juice. Wherever they feed they cause a little whitish area to appear on the upper surface of the leaf. If they are numerous every leaf may become thus mottled all over. After a time these leaves turn brownish and may even die.

Some years the leaf-hoppers are comparatively scarce and do very little damage, but other years they occur in countless numbers and attack almost every vineyard over large areas, causing the leaves to look brown and sickly, sometimes even as early as midsummer.

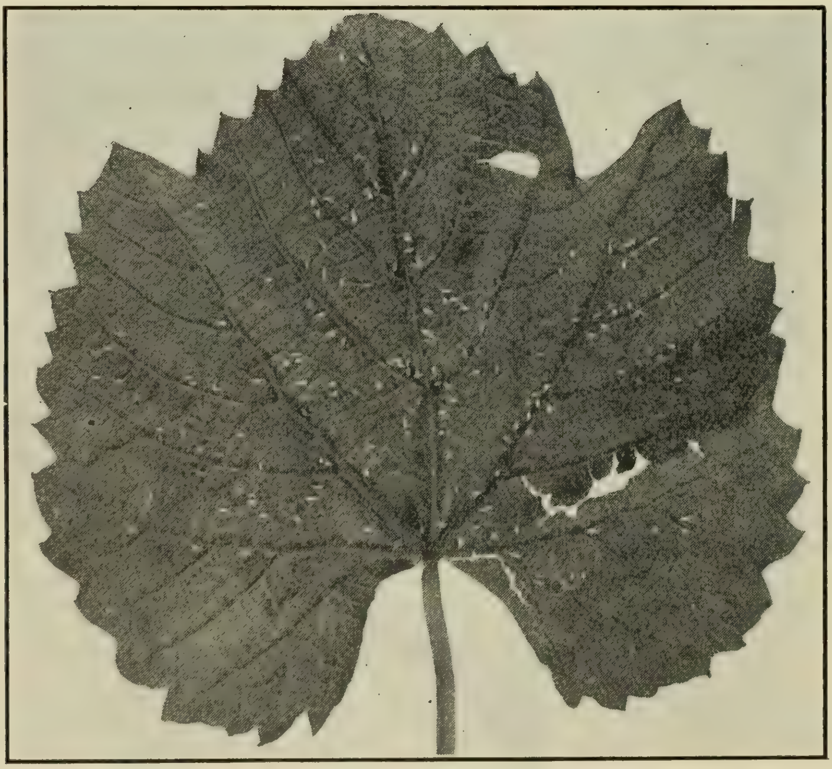


Fig. 16.—Grape-leaf hoppers on underside of grape leaf.
(courtesy W. A. Ross.)

The result of a severe attack is that the leaves, owing to the loss of the green matter in them (chlorophyll), can no longer manufacture the food necessary for ripening the fruit and for giving it its sweet characteristic flavour; hence the berries are acid and of very poor quality. Moreover this loss of green matter in the leaves prevents food being stored up in the vines and roots, and as a result the plants are more subject to winter injury than they would otherwise be and are incapable of bearing as large a crop the next year as they otherwise would.

Life History.—The winter is passed in the adult stage under leaves or brush alongside the vineyard, or in long grass, dense weeds or other rubbish in fence-corners, waste lands and roadsides. In spring, about the end of April, or as soon as growth begins, the adults leave their winter quarters and feed upon almost any kind of green weed or plant and a little later upon the leaves of fruit trees and bush fruits. When the grape foliage begins to appear and about the third leaf stage has been reached, they migrate in large numbers to the vineyards and feed upon grape leaves.

Egg-laying soon commences and continues until about the end of June. The eggs are inserted in the tissues of the under side of the leaves. After laying their eggs the adults die. The nymphs begin hatching from the earliest eggs about the middle of June and almost all eggs have hatched by about the middle of July. About this date, too, the oldest nymphs begin to transform into adults. Many of these earliest adults lay eggs and from these comes a partical second generation. When winter weather arrives or late in fall, the adults all go into winter quarters, any nymphs that have not reached that stage perishing.

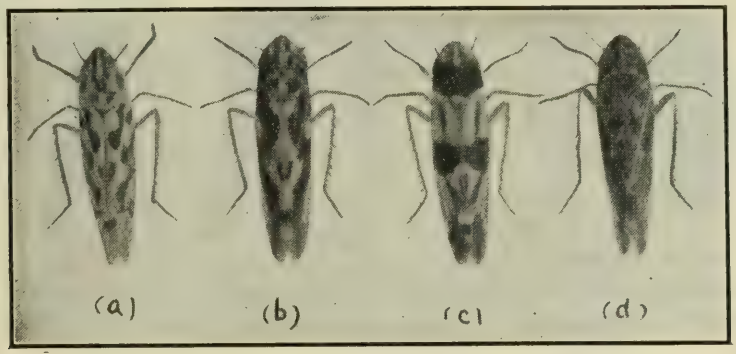


Fig. 17.—Grape leaf hopper.—Adults much enlarged.
(Courtesy W. A. Ross)

Control.—It has long been known that the nymphs can be killed by spraying with nicotine sulphate 40 per cent., but during the severe outbreaks of 1921 to 1923, Mr. W. A. Ross made the interesting discovery that the eggs, which, as said above, are laid in the tissues of the under side of the leaves, could also be killed by this same substance. He therefore recommends that if the leaf-hoppers are sufficiently abundant to be likely to cause any serious loss, the vineyard should be thoroughly sprayed about a week after the fruit has set with three-eighths pint of nicotine sulphate to forty gallons of Bordeaux mixture of the 4, 8, 40 formula. This is about the date when the greatest number of nymphs and eggs combined can be destroyed. One application, if well done, will be sufficient. Short spray rods with angle disc nozzles and high pressure are necessary. The spray, of course, must be applied to the under side of the leaves where both nymphs and eggs are.

The Bordeaux is added to ward off fungus diseases.

As the adults winter in weedy, grassy places and in thickets, considerable benefit can be obtained by burning over such areas early in spring.

GRAPEVINE FLEA-BEETLE (*Altica chalybea*)

Though sometimes very destructive, this insect is not common. It usually occurs in destructive numbers only in vineyards with surroundings which afford favourable winter-quarters for the beetles, such as those situated close to woods or to other weedy or grassy areas.

The adults are small, steel-blue beetles about one-fifth inch long. The larvae are brown with black heads and many black spots on the back. When full-grown they are about one-third inch in length.

Injury.—It is only the adults that cause any serious damage. These come out of winter quarters when the buds are swelling and attack them, eating into the interior and completely destroying them. As when pruning only a few buds are left on each vine, it does not require many beetles to do great damage and to destroy all prospects of a crop on the vines attacked.

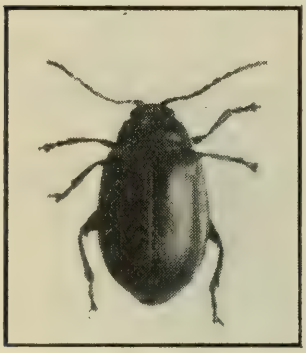


Fig. 18.—Grape-vine flea-bettle enlarged x6. (courtesy W. A. Ross.)

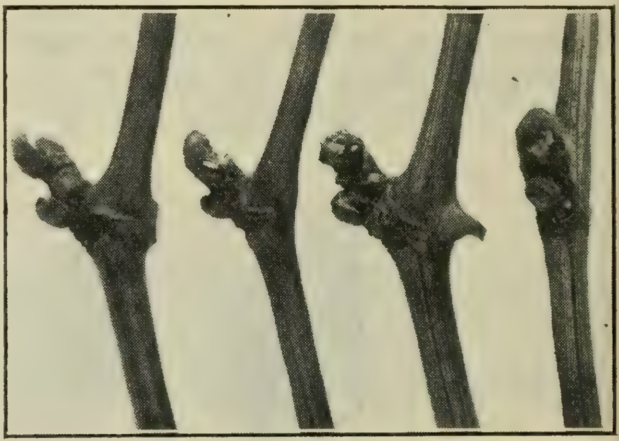


Fig. 19.—Grape-vine flea-bettle attacking grape buds. (courtesy W. A. Ross.)

Life History.—The winter, as stated above, is passed in the adult stage under the shelter of leaves, brush, grass or other rubbish near the vineyard or near wild grapes or Virginia creeper, both of which also serve as host plants. In spring the adults attack the buds, as described, and after a short time begin laying their eggs. These are placed chiefly under the loose bark of the vines or under the bud scales. The larvae which hatch from them feed upon the leaves, eating more or less chain-like areas out of them. The adults also feed on leaves after these have appeared but, as grapevines produce new leaves rapidly, any feeding done on them either by adults or larvae seldom is of much importance. The larvae become full grown early in July, then enter the ground and pupate there. From the pupae new beetles emerge in about two weeks. These beetles feed for a time on the grape foliage and in early fall go into winter quarters.

Control.—1. The cleaner the surroundings the fewer will be the beetles which will winter successfully.

2. The part of the vineyard that in previous years has been attacked by these insects should be watched in spring and, if the beetles are present, should be sprayed at once with 3 pounds arsenate of lead and 1 gallon of molasses to 40 gallons of water. Care must be taken to see that every bud is completely covered. Often it will be necessary to repeat the spraying in three or four days so that the new growth on the buds will be covered.

3. The larvae may be killed easily by spraying with 1½ pounds arsenate of lead to 40 gallons of water whenever they are seem to be present on the leaves. Destroying them lessens, of course, the number of beetles for the next year.

4. Sometimes frames about 3 feet wide and 6 feet long covered with muslin and saturated with kerosene are used to capture the beetles. They are serviceable only on bright days as the beetles hide in cool weather. The frames should be held close up against the vines and the beetles tapped into them. The kerosene on the sheets kill them but has to be renewed from time to time.

ROSE CHAFER (*Macrodactylus subspinosus*).

This is a somewhat slender beetle about one half-inch long. The body is densely covered with fine, short, greenish-yellow hairs on the thorax and yellowish-brown hairs on the wing covers, thus giving the insect a fawn coloured appearance. The beetles have long legs, are sluggish in their movements and may be captured with ease.

The larvae live in the ground, look like small white grubs and when full-grown are about three-quarters of an inch long.

Life History and Injury.—The beetles emerge about the time Concord grapes are coming into bloom and in about two weeks all have come forth. After emergence they soon fly to grapes, roses, sumach, fruit trees, strawberries and many other plants and feed upon the flowers, fruit or foliage of these. On grapes they attack and often utterly destroy the blossoms and young fruits and skeletonize the leaves. During a severe outbreak the whole crop in many a vineyard may be utterly ruined. Roses, peonies and other flowers suffer at least as severely as grapes. Severe injury is also done to the fruit of apples and to the fruit or foliage of other orchard trees. After feeding about three weeks the number of beetles begins to decrease and in a couple of weeks more they practically all disappear.

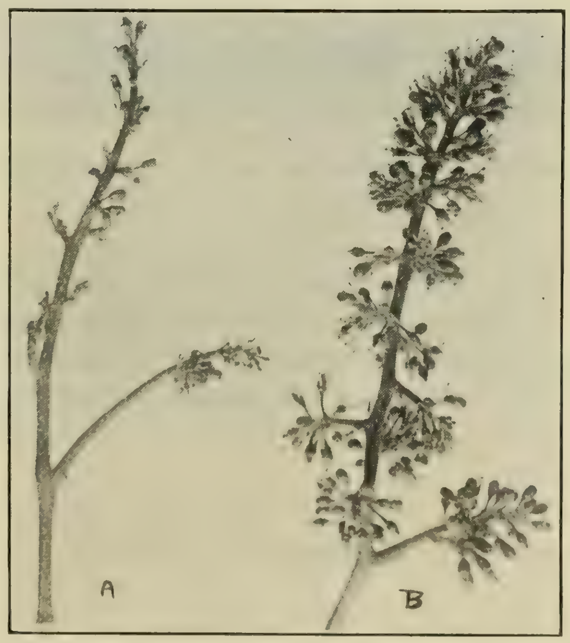


Fig. 20.—A. Grape blossom cluster destroyed by rose chafers.
B. Normal blossom cluster. (Courtesy W. A. Ross).

In the meantime eggs have been laid. They are placed in the soil chiefly in waste or grassy lands, but only where the laid is sandy; for the insect cannot reproduce in clay lands. Moreover, they do not lay eggs in well-cultivated land unless it happens to be in wheat or some closely allied crop. The larvae from the eggs live in the soil upon the roots of grasses, cereals and weeds, but as a rule do very little damage. In the fall they are nearly full-grown. On the approach of winter they work their way down below the plow line and remain there until spring when they come up to within a few inches of the surface and complete their growth. About the last week in May they pupate in the soil where they are. From these pupae adults begin emerging about the time Concord grapes are coming into bloom. There is, of course, only one brood a year.

Control.—It has been mentioned that these insects breed only in sandy land, hence clay areas are not troubled.

2. Cultivation of the soil is of great value as eggs are not laid in cultivated fields to anything like so great an extent as in uncultivated. Moreover, plowing infested land the last week in May or the first week in June kills nearly all the pupae in the soil.

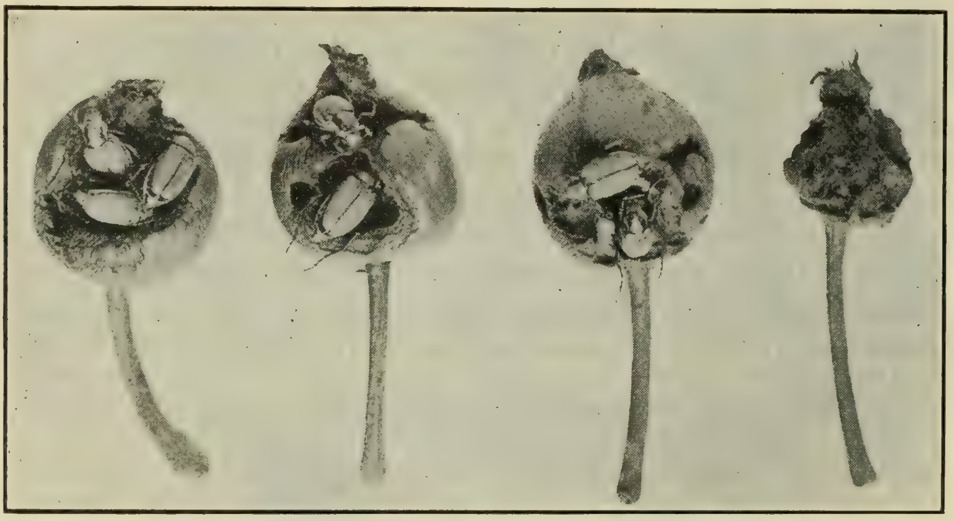


Fig. 21.—Rose chafers feeding on apples. (Courtesy W. A. Ross).

3. There should be concerted effort made in all sandy districts where this beetle is troublesome to bring all waste lands under cultivation or at least to break them up and seed them with sweet clover (Ross and Hall have found that very few eggs are laid in clover). Ross suggests that a good plan for treating these wastelands would be to re-forest them. This could, of course, be done while they are still in clover.

Attention may be called to the fact that light, sandy lands if properly fertilized can be made to grow good potatoes or tobacco.

4. Vineyards and fruit trees when attacked may be protected by heavy spraying with 3 pounds arsenate of lead to 40 gallons of water in which 1 gallon of molasses has been mixed. Usually one or two applications are sufficient. The first should be as soon as the beetles are seen to be sufficiently numerous to justify it, and the second as soon as the first has washed off or new growth makes it expedient to re-spray.

THE GRAPE-BERRY MOTH (*Polyphrosis viteana*).

This insect occurs in all parts of the Niagara fruit belt, but, fortunately, it is destructive only occasionally in a few vineyards.

The berry moth caterpillars—dark greenish or purplish worms, about three-eighths of an inch long when full-grown—web together and feed on the blossoms and newly set fruit, and a later brood attacks the green and ripening berries. The second brood worms tie the fruit together with a few silken threads; bore into the berries; pass from one grape to another and feed inside on the pulp. Infested berries become discoloured and shrivelled, and are absolutely worthless for any purpose.

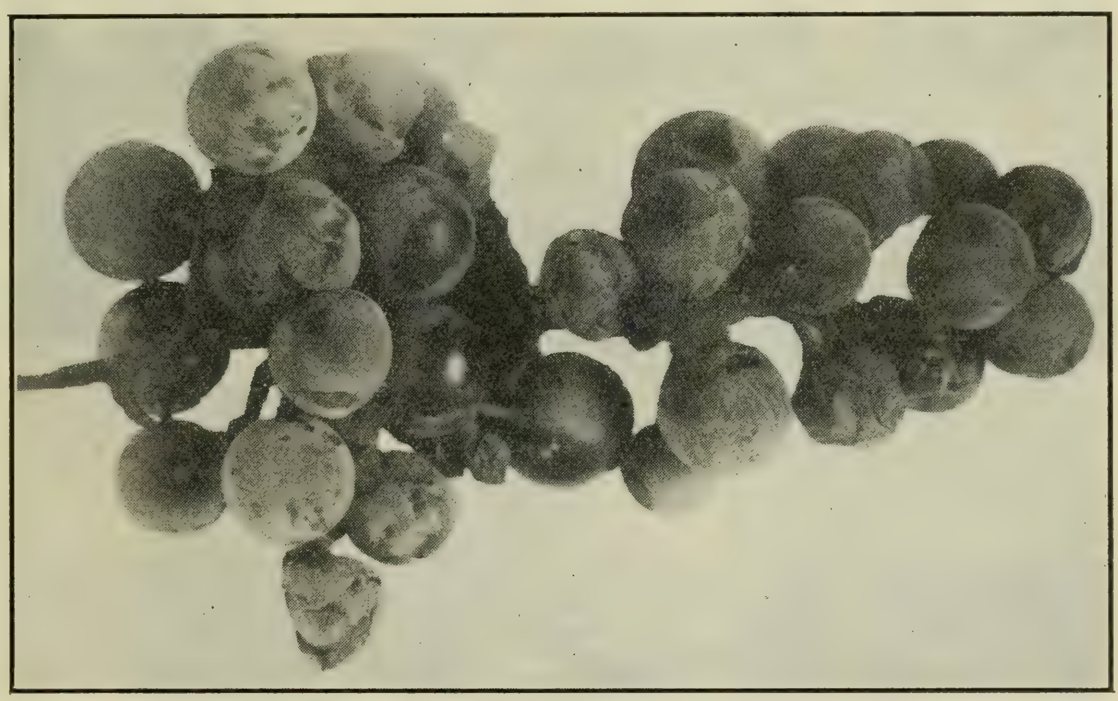


Fig. 22.—Bunch of grapes badly infested by grape-berry moth.
(courtesy W. A. Ross.)

Control.—This insect can be controlled by spraying with 1½ pounds arsenate of lead powder, and 1 pound soap in forty gallons Bordeaux mixture, immediately after the blossoms, and, in the case of severe infestations, the spray should be repeated two weeks later. In spraying for this insect, it is absolutely essential to cover thoroughly all the grape clusters with the spray material, and this can be most satisfactorily done by means of a power outfit with short rods and angle nozzles.

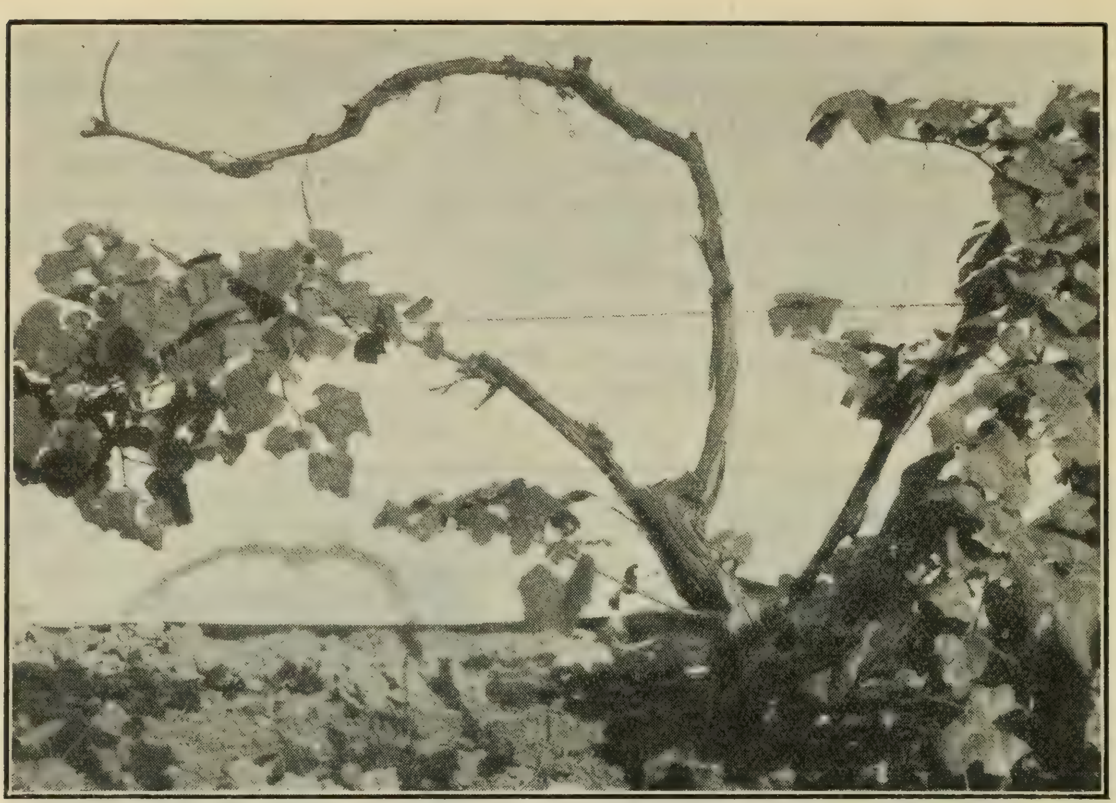


Fig. 23.—Grapevine showing an arm killed by Dead Arm.

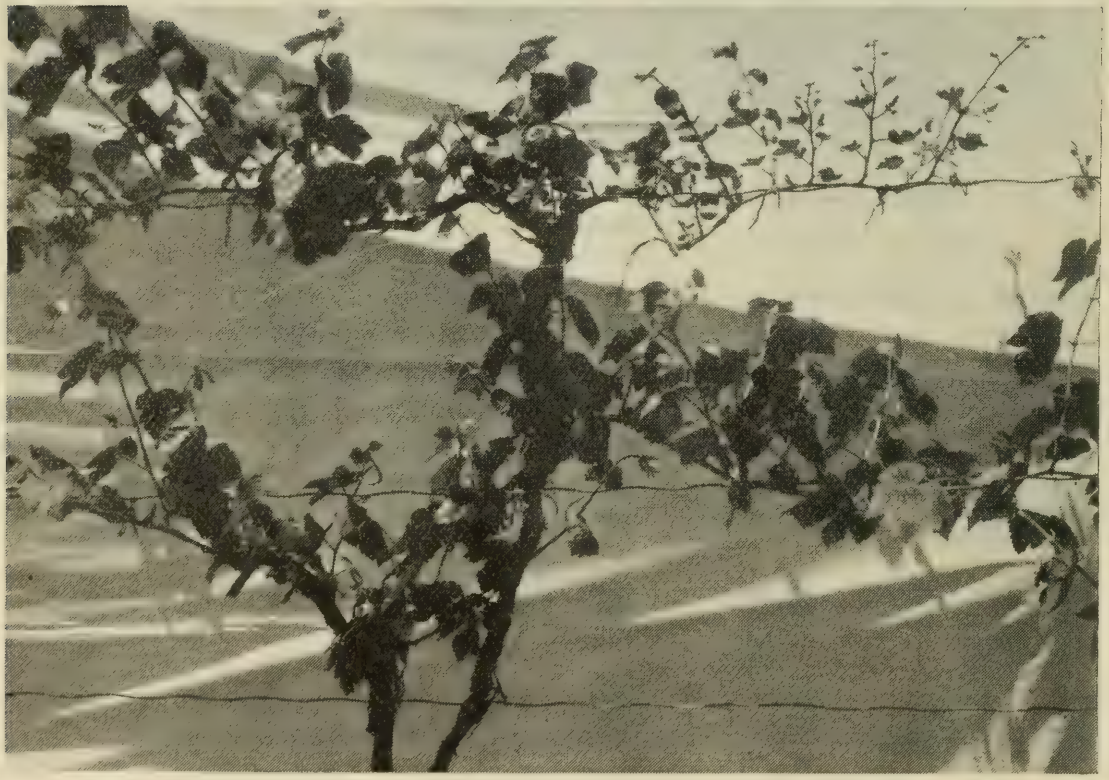


Fig. 24.—Grapevine showing upper arm to the right with dwarfed, curled and crinkled leaves—typical symptoms of Dead Arm.

GRAPE DISEASES

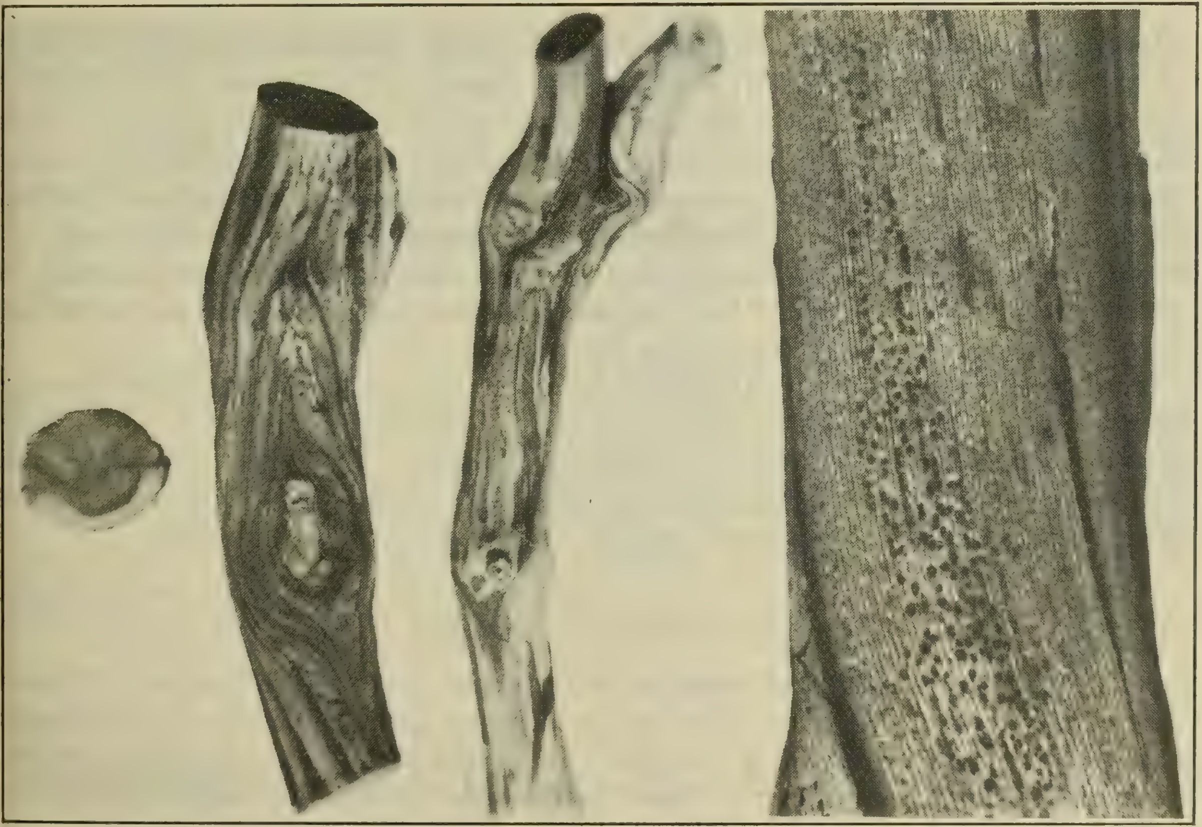
J. E. Howitt, Professor of Botany, O.A.C., Guelph

Nearly all the common diseases of the grape are found in Ontario vineyards but, fortunately, most of them do not cause serious loss over any large area of our grape growing districts. In the past, however, there have been severe epidemics of Black Rot and frequent local outbreaks of Powdery and Downy Mildew. During the past few years Dead Arm has become widespread and has caused serious loss in many vineyards. Diseases of the grape, therefore, demand the attention of the vineyardist, who should become familiar with the symptoms of the common diseases and the best methods of combating them.

DEAD ARM (*Cryptosporella viticola*, Shear)

By DR. L. C. COLEMAN, Department of Botany, Toronto University

This disease has increased in importance during recent years and is now considered by some of the grape growers of the Niagara peninsula as the most serious disease with which they have to contend. Counts made in two vineyards during the summer of 1926 showed, in one case 6 per cent., in the other 15 per cent. of the vines attacked.



b Fig. 25. a Fig. 26. Fig. 27.

Symptoms.—The most striking symptoms are (a) the appearance of a lead arm or dead arms on the attacked vine (see Fig. 23); and (b) the occurrence n arms not already killed of leaves which are small, yellowish, and curled and rinkled on the margins (see Fig. 24). This second symptom is most strikingly pparent during June and early July. Later on in the season the yellowing of he leaves, which is most pronounced around the margin, disappears, but the lwarfing, curling and crinkling remain.

Associated with these two striking symptoms, we find almost invariably on the stem one or more dead areas or lesions which lie in the line of the affected arm. These lesions are the real seat of the disease. Figure 25a shows such a lesion or dead area on a stem. The area has at its centre the stub of a branch through the pruned or broken end of which the fungus causing the disease almost certainly entered the stem. Figure 25b gives a cross-section of the stem in this region showing that here the main part of the stem tissue is dead.

Figure 26 shows a piece of stem with a large lesion which has here developed from an infection in the arm to the left and has spread down into the stem and up into the arm to the right.

Life History.—The life history of the fungus causing this disease is at present under investigation. Infection experiments go to show that spores of the fungus, which are formed in small black structures (*pycnidia*) to be found on the surface of a lesion (see Fig. 27), and which issue from the pycnidia in huge numbers during the spring and summer, germinate on pruned ends and other wounds and that the fungus thus gains its entry into the stem, gradually causing death. The disease is, in the case of older vines at least, usually present in the stem several years before the typical symptoms appear on the arms. It is rarely that one sees any dead arm symptoms in vines under six years of age.

Remedial Measures.—1. As the disease is mainly one of the stem, the removal of arms which are dead or which show symptoms of the disease is, at least in most cases, quite useless. At the time of cutting out, which should be in June, a thorough examination of the stems of all suspected vines should be made. If stem lesions are found, the stem should be cut off well below the lowest lesion. Where the lesion extends to the ground the vine should be removed entirely. The cut surface should be completely healthy in appearance and should be covered with coal tar or white lead to prevent infection. The diseased portions which have been cut away should be burned.

2. As the infection seems almost certainly to occur for the most part through pruning wounds, spring spraying or painting of these wounds with a fungicide would no doubt go far towards preventing infection. However, until the field experiments, which have been planned, have been carried out, we do not know whether or not such a treatment can be made economically feasible.

BLACK ROT OF THE GRAPE (*Guignardia bidwellii* (Ell.) Viala and Ravaz.)

In the past this was considered to be the most destructive disease of grapes. It has caused severe losses to the grape growers in some sections of the Niagara district. During recent years it has given very little trouble but has been present to a limited extent every year in some of the vineyards in the neighbourhood of St. Catharines and one or two other localities in the Niagara district, and may at any time become epidemic again if climatic conditions become favourable to its development.

Symptoms.—Black Rot affects the leaves, berries, tendrils and canes. It does most damage to the berries on which pale or light spots first appear and gradually enlarge until the whole berry is involved, turns brown and finally shrivels up and becomes hard and black with the surface covered with minute black pimples, the fruiting bodies of the black rot fungus. Such berries are called "mummies" and are frequently seen hanging on the vines. Entire bunches or only a few berries in a bunch may be thus affected. On the leaves the disease produces comparatively small, circular, brown spots with distinct dark margins. On the surface of these spots minute black specks, the fruiting bodies of the fungus, may be seen. Similar but more elongated spots are seen on the shoots.

Life History.—Numerous spores are produced in minute fruiting bodies on the surface of the diseased berries, leaves and shoots. These are discharged in enormous numbers whenever the vines are wet by rain and thus the fungus spreads during the summer months. It is interesting to note that the fungus cannot spread during dry weather as it requires considerable moisture to cause the discharge of the spores from the fruiting bodies. The fungus is carried over the winter by spores, in affected fruits, shoots and tendrils. The mummied fruits hanging on the vine or lying on the ground beneath are the chief source of primary infection in the spring.

Treatment.—Gather and burn the mummied fruits that may be on the vines. Rake up and burn the trimmings from the vines. Plow as early in the spring as is practicable, taking care to turn under the rotten bunches and leaves as completely as possible. Spray with strong Bordeaux (4-8-40 formula) first shortly before the blossoms appear, second about a week after the fruit is set, and at this time add three-eighth pint of nicotine sulphate to each forty gallons of the Bordeaux if leaf hoppers are troublesome. The necessity for other applications will depend upon the weather. During prolonged wet weather the vines should be sprayed frequently enough to keep the foliage and fruit covered with Bordeaux.

POWDERY MILDEW OF THE GRAPE (*Uncinula necator* (Schw.) Burr.)

This disease is probably the second most troublesome one in the Province at the present time. It causes very considerable damage especially to red skin varieties. Varieties derived from the European grape (*Vitis vinifera*) are said to be most susceptible to this mildew.

Symptoms.—The Powdery Mildew affects the leaves, young shoots, blossoms and fruits. It is first observed on both surfaces of the leaves as circular, whitish spots which have a finely powdered appearance. If the disease is very severe these spots may enlarge until the whole leaf is involved. Such badly attacked leaves are frequently somewhat stunted and distorted. Mildewed blossoms fail to set fruit. Berries that are attacked may cease to grow and drop, or develop irregularly and fail to ripen.

Treatment.—At first sign of Powdery Mildew dust Rogers' varieties with sulphur. Spray other varieties with Bordeaux (4-8-40). Repeat in ten days if necessary.

DOWNY MILDEW OF GRAPES (*Plasmopara viticola* (B. & C.) Beil and De Tomi.)

This is one of the commonest diseases of grapes in Ontario. It is present to some extent nearly every year and sometimes does serious damage. It seldom becomes troublesome over any great area of vineyards but is frequently found doing considerable damage to vineyards here and there throughout the grape-growing district of Ontario.

Symptoms.—The Downy Mildew attacks the leaves, berries, young shoots and tendrils. It is usually most noticeable on the leaves, on the upper surface of which it appears first as irregular greenish-yellow blotches which later become brown in colour. When the disease is severe the blotches increase in size and run into each other so that the whole leaf becomes brown and withered. On the under surface of these blotches a white downy fungus growth may readily be seen. It is a common thing to see a vine or two in a row of grapes with the leaves completely destroyed by this disease. On diseased shoots whitish patches are seen and, when the disease is bad, the shoots frequently become brown and withered. The berries are often attacked when quite small, become covered with white mildew, and cease to grow. On larger berries a half or more grown, the disease causes brown spots which increase in size until the whole fruit become brown and rotten. This stage of the disease is spoken of as brown rot.

Life History.—On the under surface of the diseased leaves, and on the surface of affected shoots and berries numerous spores are produced. These are scattered by rain and wind and thus the fungus spreads during the summer months. Continued damp weather appears to be necessary for the rapid increase of this disease. In the fall in the tissues of infected leaves and shoots another form of spore is produced. These are thick-walled resting spores which serve to carry the fungus over the winter. They are liberated into the soil by the decay of the leaves and shoots and give rise to the disease again the following summer if the climatic conditions are favourable to its development.

Treatment.—Same treatment as described for Black Rot.

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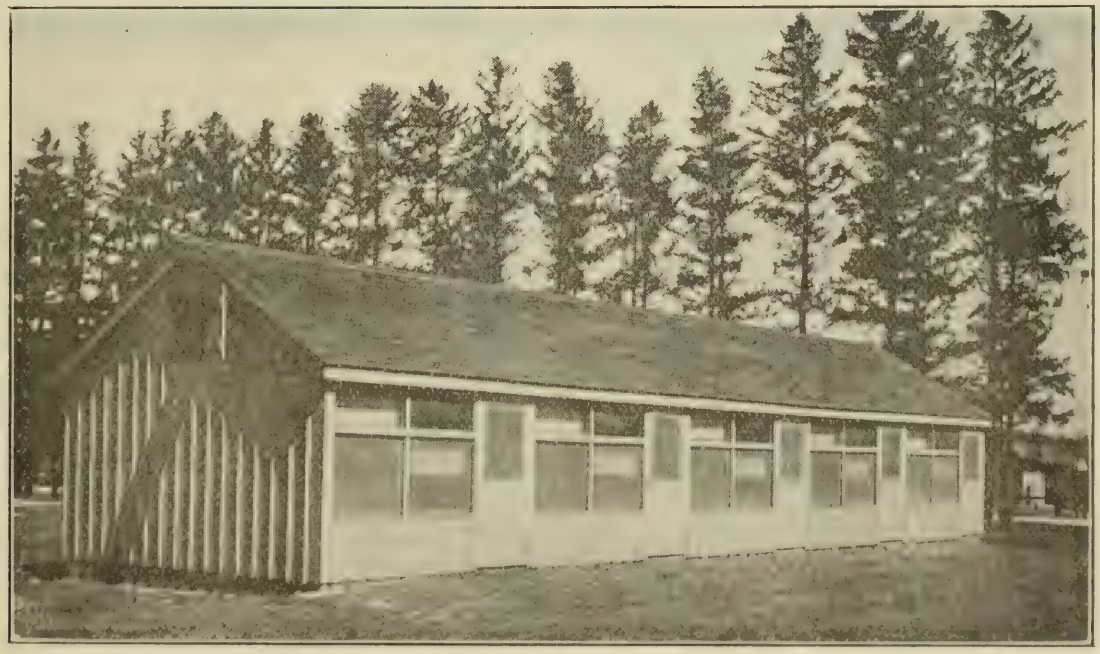
BULLETIN 329] [JUNE, 1927

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

FARM POULTRY

POULTRY DEPARTMENT



Poultry Building, Ontario Agricultural College
(See page 36)

FARM POULTRY

INTRODUCTION.

More [illegible] in poultry and poultry products is shown from year to year. Many [illegible] years ago considered poultry as a necessary evil and not in any sense of [illegible] as revenue makers. There are yet a considerable number of this class, but [illegible] people are finding that the keeping of poultry is profitable and enjoyable. We [illegible] find a large number of farmers keeping from fifty to one hundred hens, who are well pleased with the cash returns from their poultry. There is also a growing number of small farmers who specialize in poultry-keeping profitably, and further there are numerous persons in cities, towns and villages who are making money from poultry.

The writers in the following pages will endeavour to give in a concise form the results of their experience covering a period of more than twenty-five years with poultry at this College.

SUCCESS or FAILURE in keeping poultry depends upon breeding, feeding, housing, hatching, rearing, sanitation and general management. All of these factors must be carefully studied. We do not mean to infer that the keeping of poultry is extremely difficult, but we do wish to impress upon our readers that it is no business for a lazy or an indifferent person, or one who is not prepared to plan the work carefully and then work to the plan. There is a larger number of individuals in the poultry flock than in most other flocks of live stock kept upon the farm, and the individual unit is frequently lost in the mass. The writers believe poultry production will be found both enjoyable and profitable if the person in charge will do his or her part well, but we would discourage people who are not prepared to work faithfully and systematically. By this we mean success is not likely to be obtained by careful feeding, etc., for five or six days, and then on the following days forget to feed or water, etc. Where poultry is kept in large numbers, success depends almost entirely upon efficiency.

The general farmer has nearly all the conditions for success and if given reasonable attention poultry-keeping should be one of the revenue producers of the farm.

BREEDS OF POULTRY.

The present high prices of eggs and meat have done much to popularize poultry on the farm, and consequently we are frequently asked as to "What is the best breed of poultry." It is impossible to answer this question, as some breeds are special purpose breeds and others general purpose breeds. There is undoubtedly more difference in strains of the same breed than there is between breeds, and there are good and poor strains in all breeds.

It is not the purpose of the writers to discuss all breeds of poultry in this bulletin, but simply to mention the general characteristics of some of the more popular ones. We shall endeavour to classify these breeds more or less on utility lines rather than according to the usual classification as adopted in various poultry publications. It may be taken as a rule that all breeds that lay brown or tinted shelled eggs will set, hatch, and rear their young, and all breeds which lay white shelled eggs, with the exception of Dorkings, are non-sitters, and the eggs from these breeds have to be hatched artificially or by hens of other varieties. It will, therefore, be seen that the general purpose breeds lay tinted eggs and are good sitters and mothers.

GENERAL PURPOSE BREEDS.

Plymouth Rocks. There are six varieties of this breed—three of which are common—Barred, White, and Buff. The Partridge, Columbian, and Silver Pencilled are not so common. The Barred Plymouth Rock is undoubtedly the most popular variety of fowl among farmers. The best bred-to-lay strains are good winter layers, fair summer layers, make first-class roasters and fair to good broilers. It is one of the hardiest breeds. The standard weights are: Cock birds, 9½ lbs.; cockerels, 8 lbs.; hens, 7½ lbs.; and pullets, 6½ lbs. Bred-to-lay strains usually run slightly below the standard weights in all sections except cock birds, and they mature quickly.

Wyandottes. There are several varieties in this breed, among which might be mentioned: White, Buff, Silver Laced, Golden Laced, Black, Columbian, Partridge and Silver Pencilled The most popular variety from a commercial standpoint is the White. This breed has practically the same characteristics as the Plymouth Rocks, but is more blocky in type and usually longer in the feather. The feathers are not carried so close to the body as the Rocks. They have rose combs, which by some is supposed to be an advantage in cold climates. Wyandottes make good broilers and good roasters. Some strains are good layers and they make good mothers. The standard weight of these birds is one pound less than those of the Plymouth Rocks.

Rhode Island Reds. There are two varieties of this breed, single comb and rose comb. As compared with the Plymouth Rocks and Wyandottes they are longer in appearance and not so massive. They were originated by the farmers of the State of Rhode Island, and are very popular in that State. They have also grown in popularity in this country to such an extent that they now rival the Plymouth Rocks and Wyandottes. They are hardy, good winter layers, and fair summer layers. In colour they are a rich, bright red, with black tails, and more or less black wings. During warm weather our experience has been that they are more given to broodiness than the two breeds mentioned above. The standard weights of this breed are: Cock birds, 8½ lbs.; cockerels, 7½ lbs.; hens, 6½ lbs.; and pullets, 5 lbs.

Orpingtons. This general purpose breed differs from those mentioned in that they have white legs and skin; the other breeds mentioned above having yellow legs and yellow skin. The common varieties of this breed are: Buff, White, and Black. At the present time there are probably more Buff Orpingtons bred than any other variety, but the White may outrival the Buff. The Blacks are being bred more by the fanciers than by the farmers, for the reason that their black plumage and dark-coloured legs are somewhat against them for market purposes. This reed is among the best winter layers; makes good roasters and broilers, but is robably more given to broodiness during warm weather than either the Rocks r the Wyandottes. The standard weights are about one pound per bird above he Plymouth Rocks. For general farm use they might be more profitably red with less weight, for the reason that the largest birds are usually somewhat eggy and rough in appearance when weighing 4 to 5 pounds. When one wants ery large roasters, weighing from 7 to 8 pounds each or more, the larger birds, f course, would be better.

Dorkings. This is one of the oldest English breeds, and is popular in some istricts. They are a large breed, long in the body and short in the legs. By any they are considered to be weak in constitution, although our experience would not bear this out entirely. They lay large white eggs, and are good sitters and mothers. They are white fleshed and white legged. Their peculiarity is that they have five toes. This is, at times, a disadvantage, especially when the fowls have to scratch in straw where there is more or less binder twine, which is apt to get around the extra toe, and thereby occasionally fastening both feet together. This is not a very serious objection. Where there is high, dry ground and plenty of range, and a person fancies the Dorking colour or type, they are worthy of consideration.

MEAT BREEDS.

Brahmas. The feathered-legged breeds are not very extensively kept. The most popular of these is the Brahma. This breed is very hardy, and lays very large brown eggs. They are rather slow to mature and the feathers on the legs are not altogether desirable from a farmer's standpoint; in that they are apt to get wet and freeze easily. Brahmas make the best roasters, but are somewhat slow to mature, and the females, in our experience, have not been very good layers, although there are some females that do well. This breed is yellow skinned.

Games. By many the Game would not be considered a chicken suitable to farmers. The exhibition Games, as they are known in the Standard, are altogether too long in the legs and head, and too weak in constitution for the ordinary farmer, but the Cornish Games and what is known as the Old English Game are worthy of consideration. The Cornish Game is a very large, tight-feathered, full-breasted chicken, and probably carries more meat on its breast than any other breed. The objection to the Cornish Game is that it is a poor layer. The English Game, sometimes termed "Pit Game," is a hardy bird. They are fair layers and make fair roasters. The most serious objection to this breed from a farmer's standpoint is that there is a great tendency among the young cockerels to be very pugnacious. This is sometimes carried to such an extent that they kill one another. Other than this, they make a fairly good farm chicken, especially where the mothers are required to protect their young.

SPECIAL PURPOSE EGG BREEDS.

During recent years, commercial egg farms have done much to popularize this class of fowl. Of all the breeds used for this purpose the Leghorn is the most popular, and of the Leghorns the Whites are being kept in the largest numbers. They are good layers during the natural laying season, but in the experience of the writers are liable to suffer more from the cold winter weather than are some of the heavier breeds. They are, otherwise, quite hardy. It is now a well-established fact that on the average a larger number of chicks can be hatched from a given number of eggs from Leghorns than with other breeds and their chicks are easily reared. The young cockerels make good broilers, but are of no use for roasters. Leghorns can no doubt be more successfully kept in large flocks than can the heavy breeds. Cases of commercial farms keeping from three to five hundred in a flock are common, although the fact remains that highest egg yields up to the present are secured from smaller sized flocks. Of the other varieties the Browns, Buffs, and Blacks are most common, but are more popular with the fanciers than with the farmers owing to the colour.

Minorcas. There are three varieties of Minorcas. The Rose Comb Black and Single Comb Black are more commonly bred than is the White variety. This breed is larger than the Leghorn, and also lays a larger egg. They have very large combs and wattles.

Anconas. This breed might be termed a speckled or mottled Leghorn. They have all the characteristics of the Leghorn and are black and white in colour. This breed is gaining in popularity among the practical poultrymen.

Hamburgs. There are several varieties of this breed. The Black is the most popular. They are inclined to lay an undersized egg. We have found the Blacks to be good layers, and to lay a fair-sized egg. They have rose combs and are neat and active in appearance.

POULTRY BREEDING.

There are two main points to be considered: First, the selection of birds that have the characters desired; and secondly, a further selection from these of birds that can produce offspring as good as or better than themselves.

Many are of the opinion that "Like begets like." In general, this is true, but it is true for general and not for particular qualities. It is true that a male White Leghorn mated to White Leghorn females will breed chickens that are White Leghorns, or that have white plumage, yellow legs, and white earlobes. But of these offspring there will be no two chicks exactly alike. We find large and small Leghorns; most of them never go broody but some do; some lay large eggs, others small eggs. And we find a great variation in the number of eggs produced by different hens.

Selection is made on the basis that like will produce like, but experience has taught all breeders that to secure uniform superiority, they must carry on the selection through generations of poultry. If we select birds that have laid better than 200 eggs in twelve consecutive months and mate these to a male of similar strain, we do not expect to get all daughters that will lay 200 or more eggs a year, but we do expect upon the average a better production than had no selection been made.

SELECTION.

The first step in the breeding of poultry is the selection of the birds to make the breeding pen. What birds are used in the pen depends upon what is the object of the breeder; for example, one person may be interested solely in meat production, another only in egg production, another may be careful of breed type and colour, and still another of all of the above and many more.

Selection is made along the lines of the ideal in mind. It, therefore, is advisable for one to try to form an ideal, and the higher the ideal the fewer will be the individuals that will be considered suitable for the breeding pen.

No matter what may be the breeder's ideal all agree that vigour is the one essential point that must always be present; that is, a bird must be healthy and active and able to defend the flock. Vigour means the bird's ability to thrive and live under ordinary conditions. The lower the vigour, the more easily the birds will sicken and die. Perhaps the male that is the boss of the entire flock is the most vigorous, or at least it would be safe to say he has considerable vigour.

It is essential that the breeder should bear in mind that the various characters of the chicken may be inherited separately. Because Plymouth Rocks, for example, have single combs, red ear-lobes, and yellow legs, it does not mean that all birds that have yellow legs must have single combs and red ear-lobes. By means of this inheritance of single characters, the breeder is enabled to correct single defects in the birds bred, and at the same time maintain and improve the good points.

It is, therefore, plain that the first essential is the selection of birds that have the characters wanted, and the next step is to test their power to transmit these characters. Our experience has been that certain birds, male or female, are excellent in breeding one character but fail in others. For instance, hen H19 has never bred a bird without positive bright yellow legs; she appears to be able to transmit this character to all her offspring. Again, we find birds that transmit several desirable characters very well, but may likewise transmit one very undesirable character; as an example of this, male 2227 produced daughters that were very satisfactory in all respects with the exception of size and colour of eggs. In the end the breeder selects, then tests the selected birds as to whether they can produce offspring as good as or better than themselves.

The most interesting and at the same time the most progressive method of breeding is to know the parentage of each chick, and thus to be able to tell which birds are reliable breeders. Our experience is that there is as great difference among birds in their ability to transmit certain characters as one may find in any ordinary selecting process among a pure-bred flock. Some birds are good breeders; others appear to be of very little account.

The more selections that are made and the more tests of progeny, the less is the percentage of undesirables found. One may expect some considerable variations within a group, but one may likewise expect a smaller number of inferior stock with each generation.

SELECTION AND PROGENY TESTING.

The following tables give the results of a test from four Barred Rock males and the hens bred to them that had four or more daughters which completed a year's trap-nest record. They include all the daughters from these hens that lived throughout the year.

Four daughters from a hen that laid two hundred or more eggs appear to be very few, but it must be remembered that the ordinary hatching season extends over a period of about six to eight weeks, and that about one-half the progeny are cockerels. Likewise, an ordinary hatch is fifty per cent. of the eggs set, and about twenty-five per cent. of the chicks hatched are lost through one cause or another.

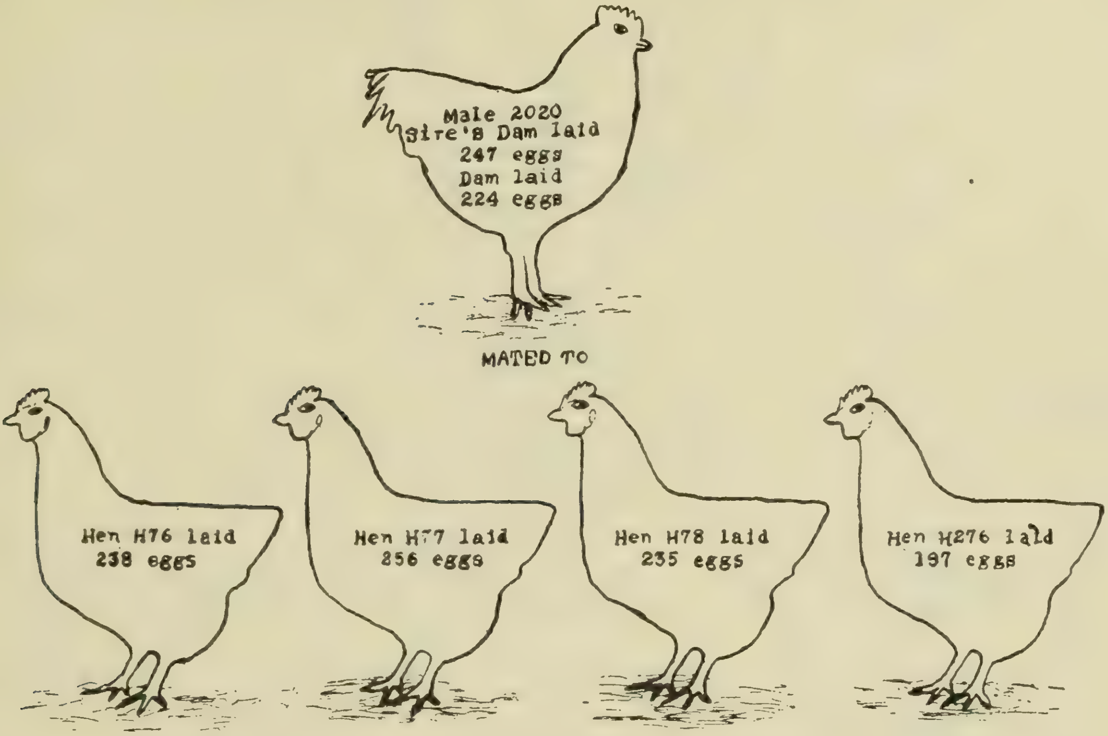
Our experience has been that four pullets from a hen is a reasonable number. Of course, if we were to set all the eggs over a three or four month's period many more pullets might be expected.

Where a hen has fewer than four pullets it is more difficult to estimate her value as a breeder. In the following table we have left out all such hens. The results from them do not alter the indicated value of the male as breeder beyond the figures given. They are of some interest in establishing the value, but where space is limited it has been considered wise to leave such hens out of the figures given.

It must be remembered that in this progeny test only the number of eggs laid are considered. There is some indication as to the hen's ability to get pullets, as is indicated by H237, H19, and H262.

A practical breeder would have to bear in mind such things as breed-type and colour, size and colour of eggs, hatchability, growth of the chicks, and the number of eggs to get a mature bird.

RESULTS OF BREEDING MALE 2020 TO HENS H76, H77, H78 and H276.



Daughters	Daughters	Daughters	Daughters
L 379 — 171	L 45 — 189	L 106 — 157	L 319 — 177
L 440 — 253	L 311 — 162	L 194 — 245	L 416 — 166
L2,631 — 133	L 386 — 221	L 479 — 165	L 487 — 184
L3,433 — 162	L2,637 — 171	L2,518 — 123	L2,551 — 155
L3,220 — 151		L2,607 — 115	L2,641 — 172
			L2,649 — 141
			L3,429 — 139

NOTES ON MALE 2020.

Male 2020 is the son of a 224 egg hen. The dam of his sire laid 247 eggs.

He was successfully bred to four hens which produced four or more daughters with trap-nest record for a year.

The mating produced three hens that laid two hundred or more eggs in their first year.

H76 produced the highest laying daughter. This is one better than the mother.

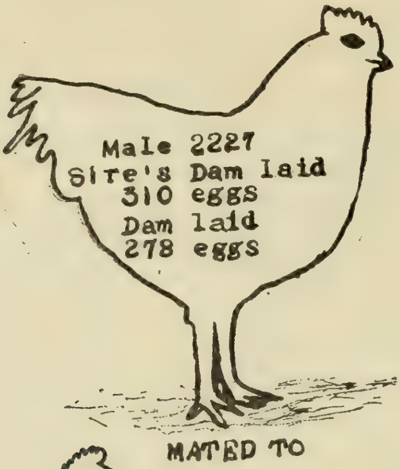
H77 produced one daughter which laid two hundred eggs, but not as good a layer as H77.

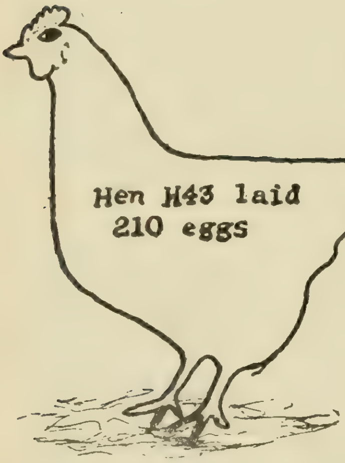
H78 produced one daughter with record higher than the mother's.

H276 produced no daughters equal to herself.

Considering everything, this mating would be considered very ordinary from the results obtained. From such a mating one would not expect future generations to be any better.

RESULTS OF BREEDING MALE 2227 to HENS H31, H43, and H237.





Daughters		Eggs laid
L 208	—	260
L 375	—	228
L 491	—	194
L2,526	—	130
L2,557	—	179
L2,572	—	191
L2,628	—	123
L3,436	—	193

Daughters		Eggs laid
L 303	—	219
L 377	—	271
L2,529	—	242
L2,575	—	254

Daughters		Eggs laid
L 70	—	202
L 221	—	204
L 318	—	227
L 352	—	244
L 400	—	227
L 437	—	224
L 474	—	249
L 492	—	223
L2,516	—	213
L2,582	—	190
L2,630	—	243
L3,905	—	235

NOTES ON MALE 2227.

The general results of this mating are exceptionally good. Our experience has been that but few matings produce as many high laying stock as this one.

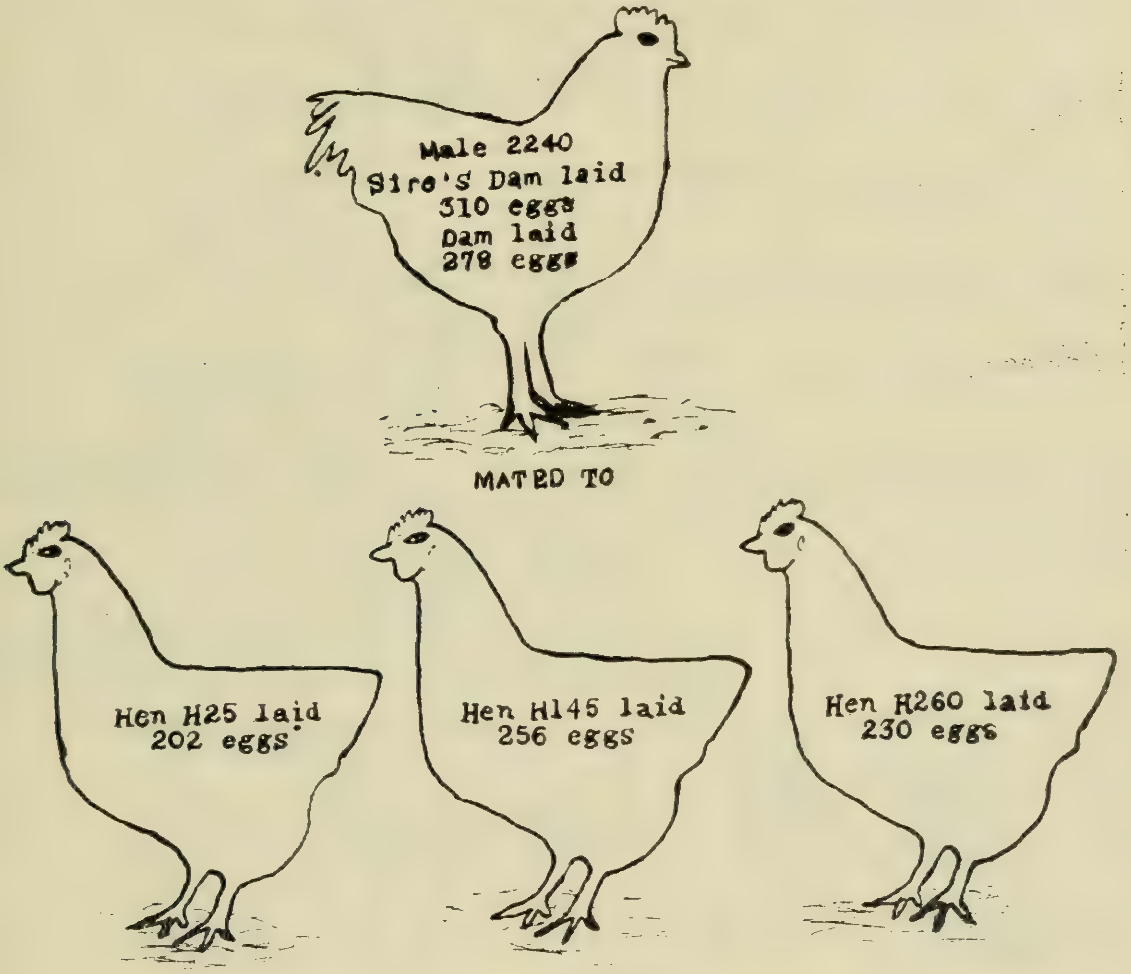
Hen H31 produced every daughter better than herself. She also produced the highest laying individual.

Hen H237 had a large number of daughters, indicating exceptional breeding ability for numbers. It is rare to get a hen with so many daughters that are all good layers. This is a very excellent hen and should be good foundation for a high laying family.

H43 does not breed as many high laying daughters and there is a wide variation among them. It is questionable if this hen had been bred to an average male whether her offspring would be very good. Sons of Hens H237 and H31 should be good males from which to breed.

RESULTS OF BREEDING MALE 2240 TO HENS H25, H145 and H260

(Male 2240 is a full brother of Male 2227)



Daughters		Eggs laid
L 15	—	169
L 404	—	211
L. 451	—	183
L 483	—	214

Daughters		Eggs laid
L 407	—	224
L 439	—	145
L2,612	—	147
L3,208	—	187
L3,210	—	134
L3,215	—	147
L3,237	—	183

Daughters		Eggs laid
L 369	—	263
L 392	—	202
L2,573	—	233
L2,599	—	105
L2,648	—	180

NOTES ON MALE 2240.

The daughters of male 2240 are, on the average, distinctly lower in egg production than those of his brother, 2227.

Hen H260 and H25 indicate that they would breed good stock. Particularly would one desire to see the offspring from such a male as 2227.

Hen H145 has no daughters equal to herself and most of the daughters are low producers. This hen might be discarded as a breeder.

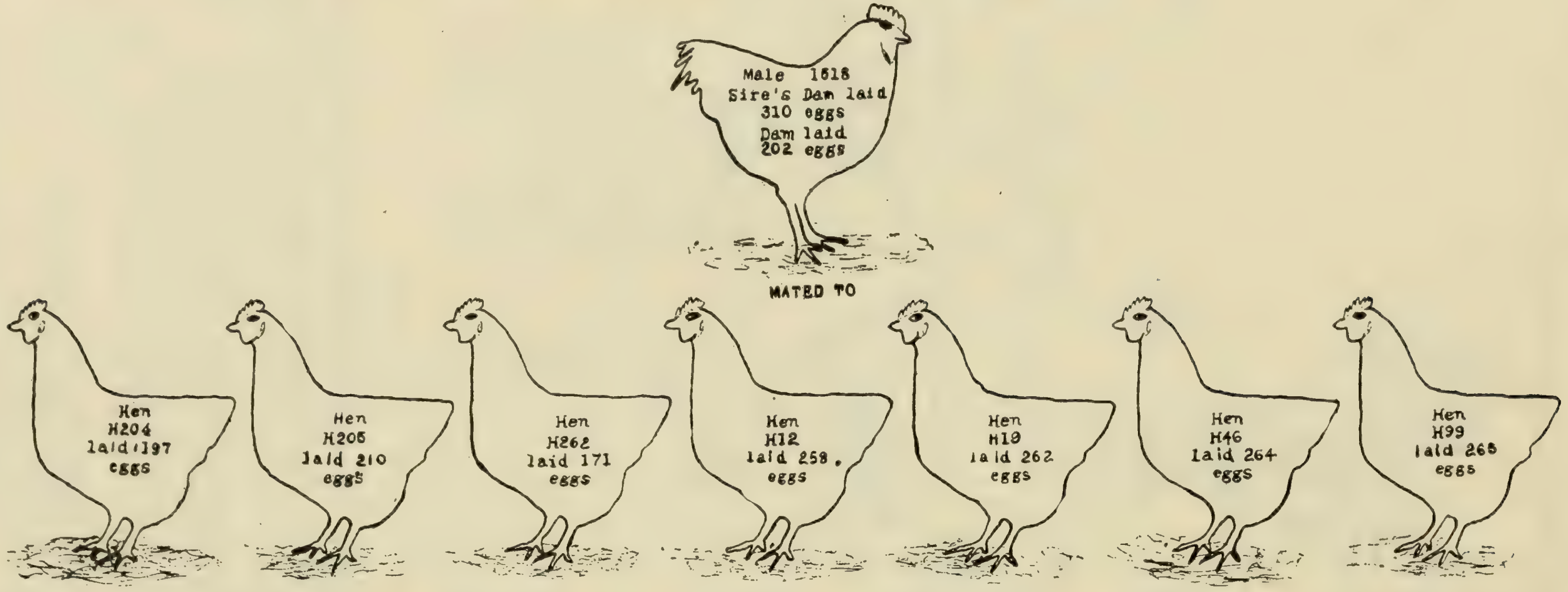
Hen H260 has one very poor daughter. Without further trials it is questionable what bearing this should have on future breeding.

Hen H25 has two daughters better than herself.

The good pullets from H260 and H25 would be worth breeding trials. The cockerels might be good breeders but one would prefer them from a better male.

RESULTS OF BREEDING MALE 1518 to HENS H12, H19, H46, H99; H204; H205; and H262

(Male 1518 is a half brother of 2237 and 2240)



Daughters		Eggs laid
L 411	—	143
L2,571	—	221
L2,594	—	144
L3,224	—	179

Daughters		Eggs laid
L 453	—	137
L2,578	—	116
L2,613	—	180
L3,231	—	166
L3,249	—	199

Daughters		Eggs laid
K 196	—	229
K 223	—	218
K 255	—	215
K 311	—	201
K 319	—	181
K 330	—	211
K 366	—	164
K 407	—	150
K 498	—	116

Daughters		Eggs laid
L 28	—	210
L 51	—	242
L2,542	—	190
L2,547	—	234
L2,556	—	216
L2,626	—	234
L3,924	—	212

Daughters		Eggs laid
K 65	—	277
K 94	—	278
K 119	—	137
K 188	—	198
K 190	—	203
L 193	—	210
L2,508	—	144
L2,531	—	180
L2,532	—	187
L2,580	—	166
L3,202	—	168
L3,294	—	160
L3,423	—	222
L3,901	—	209

Daughters		Eggs laid
L2,513	—	105
L2,548	—	263
L2,576	—	157
L2,640	—	95
L2,643	—	190
L3,442	—	161
L3,912	—	196

Daughters		Eggs laid
L 139	—	224
L 346	—	164
L 359	—	222
L2,512	—	131
L3,203	—	168

NOTES ON MALE 1518

Male 1518 was successfully bred to more hens that produced four or more daughters than any of the other males. He is rather an interesting male in that he has produced many variations, not only in the range of egg production from his daughter but in the way the daughters perform from the different hens.

The most successful mating was H12. The daughters of this hen are uniformly good.

H46 produced a wide range of daughters and the average results are not very good,

Hen H19 produced some very high laying daughters and the average of all is very good.

H99 performed much after the manner of H46, only the average is better.

Hen H204 is in the same class as H46 and H99.

Hens H205 and H262 are full sisters and therefore the results from these two hens become very interesting. It will be noted that it is not always the highest laying hen that is best bred, nor yet the lowest—(Compare H12 and H262).

The Hens H205 and H262 are an excellent example of the value of testing the progeny for the characters under consideration.

Hens H46, H99 and H204 appear to be rather inferior breeders.

TABLE I. GENERAL RESULTS FROM ALL THE HENS

Mother	Egg Production of Mother	Number of Daughters	Average Egg Production of Daughters
H12	258	7	219.7
H25	202	4	194.25
H31	213	4	246.5
H43	210	8	187.25
H46	264	7	162.4
H76	238	5	174.
H77	256	4	185.75
H78	235	5	161.
H99	265	5	181.
H19	262	14	195.
H237	224	12	223.4
H145	256	7	166.7
H204	197	4	171.75
H260	230	5	196.6
H276	197	7	162.
H205	210	5	159.6
H262	171	9	187.2
Total Production	3,888	112	3174.1
Average Production	228.7		186.71

It is not to be expected in the general results from a selected number of hens that are high layers that all the daughters will be high layers, or that the mother, only, controls the producing ability of the daughters.

Study the following tables as to the variations in breeding ability:

TABLE II. THE INFLUENCE OF THE MALE

		Mother's Egg Production	Number of Daughters	Average Egg Production of Daughters	Total Eggs
Male 1518 Bred to—	H 12	258	7	219.7	1,538
	H 46	264	7	162.4	1,140
	H 99	265	5	181.	905
	H 19	262	14	195.	2,730
	H204	197	4	171.7	687
	H205	210	5	159.6	798
	H262	171	9	187.2	1,685
Total		1,627	51	1,276.6	9,483
Average		232.4	..	182.3	185.9
Male 2020 Bred to—	H 76	238	5	174	870
	H 77	256	4	185.75	743
	H 78	235	5	161	805
	H276	197	7	162	1,134
Total		926	21	682.75	3,552
Average		231.5	..	170.6	169.1
Male 2227 Bred to—	H 31	213	4	246.5	986
	H 43	210	8	187.25	1,498
	H237	224	12	223.4	2,681
Total		647	24	657.15	5,165
Average		215.6	..	219.	215.2
Male 2240 Bred to—	H 25	202	4	194.25	777
	H145	256	7	166.7	1,167
	H260	230	5	196.6	983
Total		688	16	557.5	2,927
Average		229.3	..	185.8	182.9

SUMMARY.

Of the four males under test, male 2227 is the best breeder of high laying hens and male 2020 is the poorest.

Male 1518 breeds some good ones and by careful selection a very good line could be established, especially from the cockerels of H12.

If one desired high laying hens and considered this character only, by taking male 2227 and hens H12, H31, H237, H19, H262, H25, H260 and H77 he would be reasonably sure of getting a number of pullets that should average at least two hundred or more eggs each.

Male 2240, being full brother of 2227, and having proven himself an inferior breeder, would be discarded.

As a matter of fact male 2227 has a fault, in that his daughters do not lay a good egg for size and colour, and the breeder might consider seriously the mating of 1518, who does produce pullets laying eggs of good size and colour, in preference to male 2227; or a cockerel from hen H12 bred to the daughters of 2227 would be a mating worth serious consideration.

The remaining hens, if one was short of breeders, could be tested another season to different males, but one is not likely to get a very high average from them. Hens like H46 that have laid two hundred and sixty eggs are likely to be tested on several males in the hopes one may find a male from which she will produce her equal or better. Occasionally one is successful.

Our experience has been that by breeding from what appear to be the best sons of the good breeding hens a little progress is made from year to year, whereas taking a male simply because his mother was a high layer frequently results in a decrease in production.

Pedigree breeding and progeny testing take considerable time and accurate records. Where one desires to buy males or females from such stock the purchaser may expect to pay a higher price for such stock. The labour alone involved in pedigree breeding, if well done, will double the cost of the chicken.

Considering that many are interested in what happens when an ordinary hen is bred to a male from a fairly good hen, a male such as 2240, the following results are given:

Hen 114 laid one hundred and twenty eggs in her pullet year; from her, five daughters were tested with the following results:

K261	laid	156	eggs
K263	"	221	"
K365	"	135	"
K453	"	135	"
K489	"	147	"

or a group average of 158.8 eggs.

Experience has demonstrated many times that with reasonable care and feeding an average flock egg production of one hundred and fifty eggs can be secured, or even better, by using sons of two hundred egg hens, but to secure a flock average of one hundred and eighty to two hundred or more eggs from flock of three hundred to one thousand, requires careful breeding.

IN-BREEDING AND LINE BREEDING.

Having located a successful mating, one can perpetuate easily so long as the originals are breeding, but the problem begins after the first mating ceases. Shall one breed mother and son, or brother and sister, or cousins, or what is the best procedure?

Our experience in breeding birds of very close relationship, such as mother-son, or brother-sister matings, would not warrant us recommending such a procedure. It is true that we have had some successful results, but it is likewise true that most of such matings have been very bad. If one is anxious to breed closely, our experience would suggest a trial of any relationship, so long as the birds are vigorous, but it is not wise to depend entirely upon such a mating. A good in-bred bird will likely be a valuable breeder, but such a bird is difficult to produce.

It is very doubtful if one can say what relationship will give the best results, but to the average person it would appear to be good advice not to breed too closely, and to look for new blood from some source where the breeding has been similar.

EGG PRODUCTION.

It is generally considered among poultrymen that the production of eggs is the most profitable branch of the business. It must also be conceded that for most people a crop of chickens must be reared annually, and the surplus males and old hens sold, at a profit, if possible.

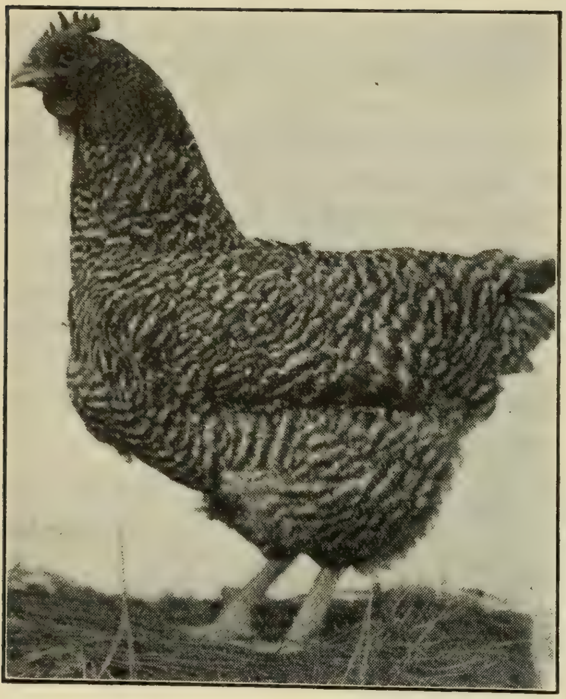


Fig. 3. H69 laid 249 eggs in her pullet year.

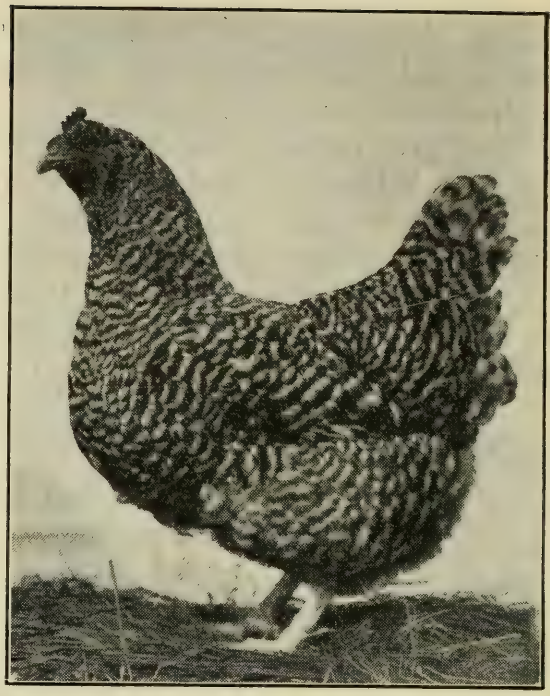


Fig. 5. K182 laid 220 eggs in her pullet year, 198 in her second year.

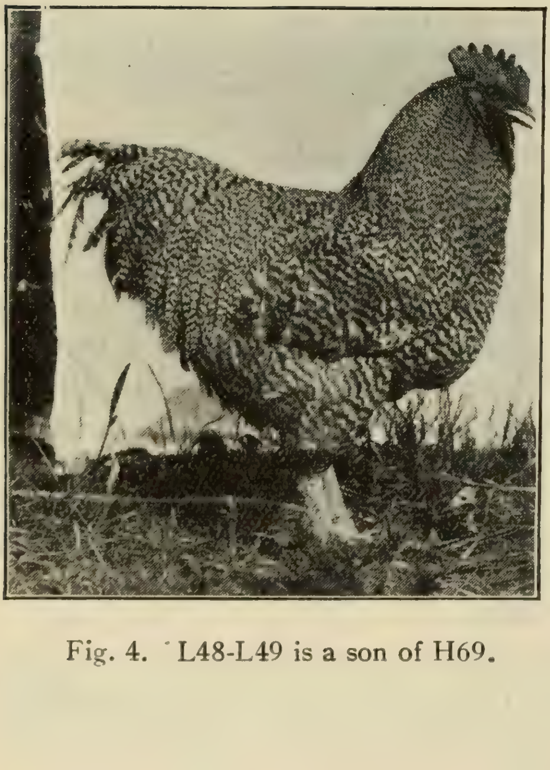


Fig. 4. L48-L49 is a son of H69.

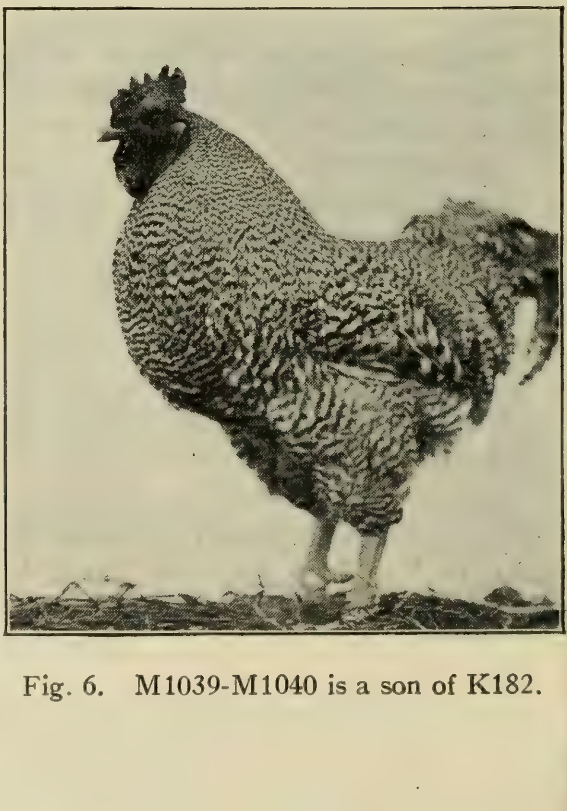


Fig. 6. M1039-M1040 is a son of K182.

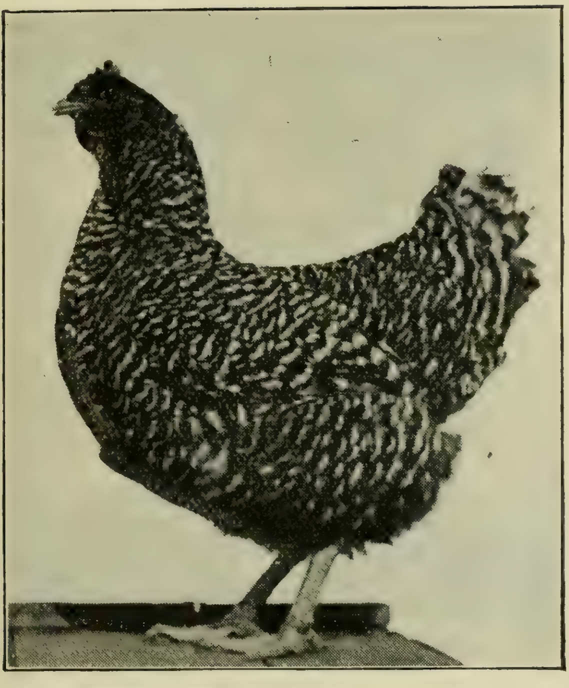


Fig. 7. H7 laid 219 eggs in her pullet year, 194 in her second year, 181 in her third year.

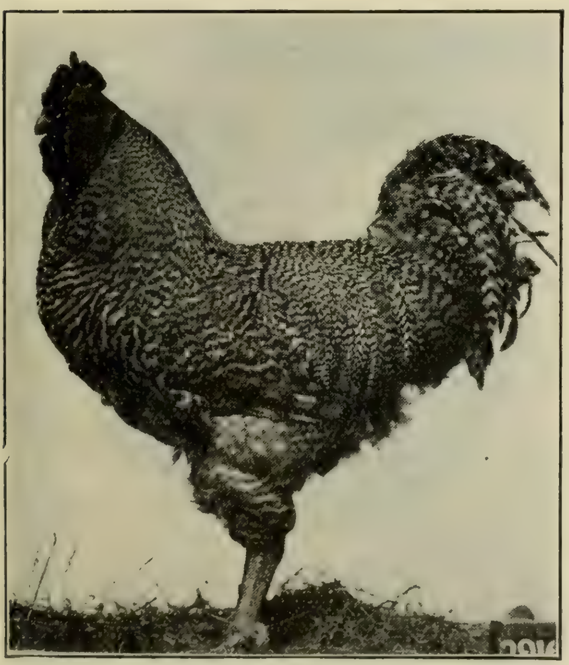


Fig. 8. M2220-M2221 is a son of H7.

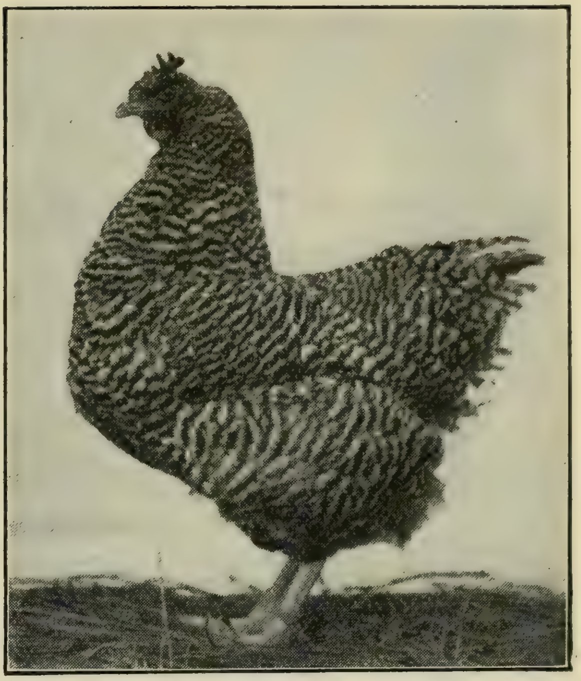


Fig. 9. K67 laid 240 eggs in her pullet year.

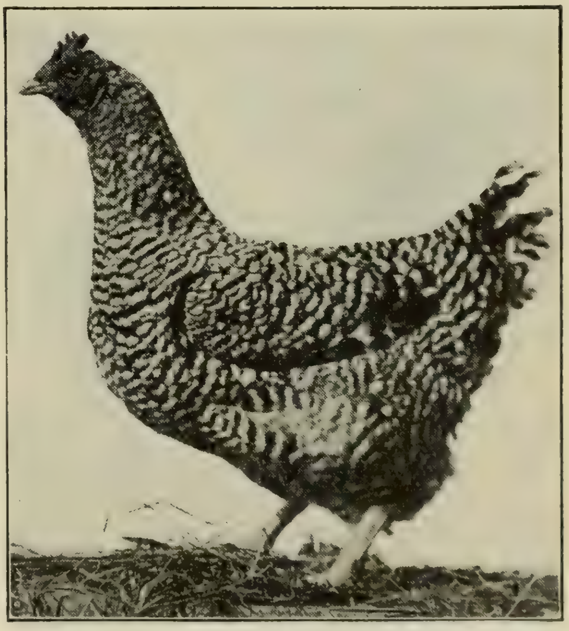


Fig. 10. H19 laid 262 eggs in her pullet year.

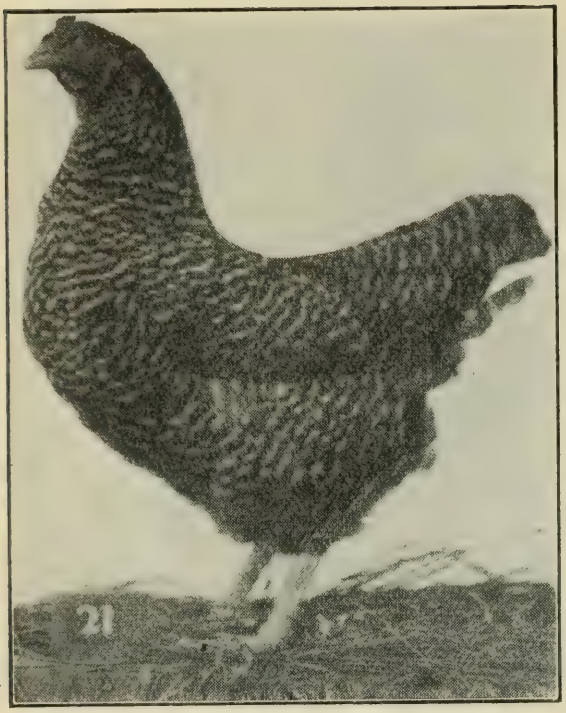


Fig. 11. L60 laid 301 eggs in her pullet year.

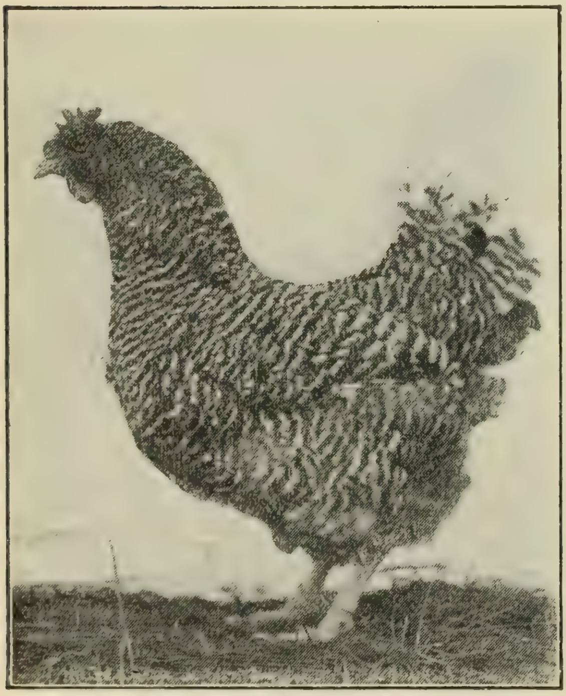


Fig. 12. K1801 laid 253 eggs in her pullet year, 196 in her second year.

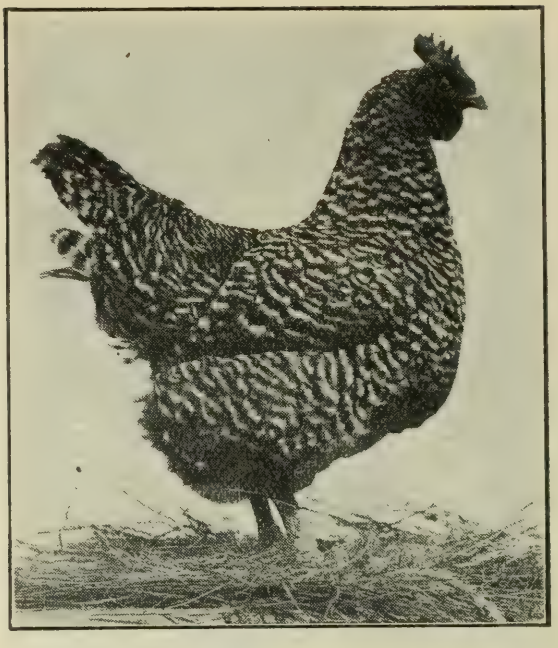


Fig. 13. K186 laid 271 eggs in her pullet year.

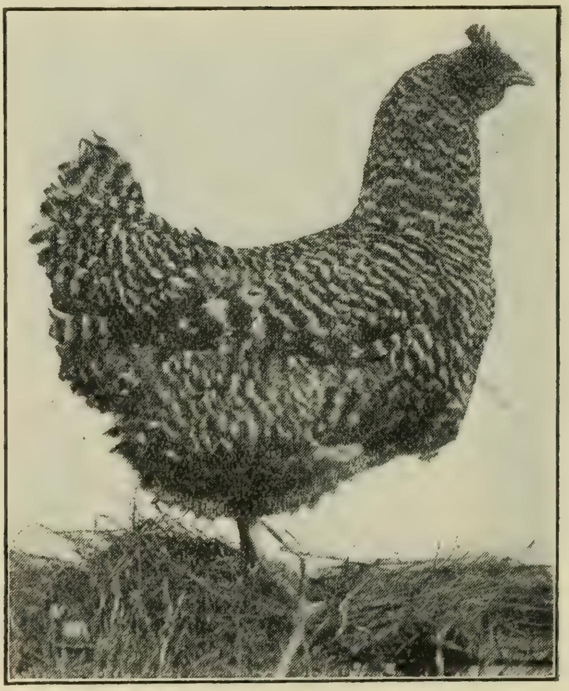


Fig. 14. G29 laid 202 eggs in her pullet year, 194 in her second year, 180 in her third year, 143 in her fourth year.

Many people appear to believe that the secret of getting eggs, particularly in winter, is in the feeds given and the method of feeding; others believe the whole problem is in the breed or strain; while others think that the housing is the problem to solve. All these are important, but the main reason for poor results, in the opinion of the writers, is a lack of careful work months before the eggs are wanted. While you are collecting the high-priced winter eggs you should be making careful plans to secure the crop of pullets for next season.

The factors are feeding, housing, age of stock, strain, possibly breed, attendance, cleanliness and the weather. All of these may be more or less controlled, with the exception of the weather and it is perhaps the least important factor.

Some troubles are: Overcrowding in houses; stock of mixed ages, that is there are two-year-olds and upwards, early pullets and late pullets; surplus cockerels; dirty, moist, draughty houses, wet or dirty litter.

Where eggs in winter are wanted the early hatched pullet is, without doubt, the one to depend upon. Yearling hens and those older are very rarely good producers during November and December. They are uncertain even in January and February and really do not begin to lay well until March. Where the egg production falls below fifteen per cent. during the winter months, one is not making much profit. The age at which most pullets begin laying is from six to seven months; some lay at four and one-half to five months, and others not until eight or nine months of age. This means that if a fifty per cent. egg yield is wanted in November the pullets should be hatched during March or April; May hatched pullets will lay a little, but, as a rule, not forty or more per cent. daily.

The attendant has responsibilities. There should not be any neglect on his or her part, but careful, constant regular attendance and a keen interest in the welfare of the birds. A bird that has stopped laying is very hard to start. As pullets mature, they commence laying; it is the attendant's work to keep them going.

The questions of the amount of feed a hen will consume, the number of eggs she will lay, and the time at which she lays the eggs, are interesting and important. Data collected in the past would indicate that one hundred to one hundred and ten eggs per year would pay for the hen's keep, according to the market prices for feed and eggs, and providing the flock mortality is not in excess of ten per cent.

The body weight must be maintained or increased if production is to be kept up.

The amount of feed consumed varies with the breed and with the number of eggs produced. Our figures show that the general purpose breeds, such as Plymouth Rocks, Rhode Island Reds and Wyandottes consume from eighty to ninety pounds of grain and mash annually, averaging nearly seven pounds of grain each month. Breeds such as Leghorns or Anconas eat from fourteen to eighteen pounds less, or the large birds eat more than small ones, and the heavy layers eat more than the poor layers. The amount of feed required cannot be stated in ounces for each day as bird's appetites vary similar to human beings. The successful feeder studies his flock and regulates the amount of feed given according to the condition and requirements of his flock. The writers are of the opinion that there are more hens too lean to lay than there are too fat. Most very fat hens are poor layers and are better put on the market than fed sparingly to try to condition for laying.

In table No. 3 are given the results of some investigations in feeding. The work has been carried on over a period of six years with Barred Plymouth Rock and Single Comb White Leghorn pullets hatched at different dates from March 1st to May 31st. The birds have, for the most part, been kept under rather closely confined conditions, the yards providing in most cases only sufficient room to allow the birds to get out of the pen and on to the soil.

In computing the above data feed used in the form of green feed has not been included. The main consideration in this connection, however, is the oats used for sprouting purposes. It is difficult to determine the exact amount of this particular feed consumed by each bird. In observations and calculation made during the past four years, during which time sprouted oats have been fed throughout the entire year, it has been found that the consumption is approximately fifteen pounds for Leghorns and seventeen pounds for Rocks. Thus it will be found that if these amounts are added to the amounts of grain and mash given in the foregoing table that total grain consumption per bird per year is for Leghorns 71.59 pounds and for Rocks 88.45 pounds.

TABLE III. FEED CONSUMED

Description	Milk	Grain	Mash	Grit and Shell	Special Animal Feed	Eggs laid
	lbs.	lbs.	lbs.	lbs.	lbs.	
1312 White Leghorn Pullets.......	102,963	50,535	23,725	3,233.5	1,569.5	197,813
Average per bird	76.11	38.51	18.08	2.46	1.19	150.7
2375 Barred Rock Pullets.......	235,698	128,102	42,625	6,372	....	381,503
Average per bird	99.24	53.51	17.94	2.21	....	160.63

A study of the distribution of the egg production is interesting and important from the point of the annual returns from the birds Egg prices rise and fall with the seasons and usually the greatest profit is made where producing eggs at a season or seasons of the year when prices are high. Pullets are the chief source of egg supply. As stated previously, they require usually from six to seven months in which to mature. It is, therefore, possible to regulate their production in the fall months at least to some extent by regulating the time they will hatch in the spring. Below is given the average percentage monthly egg production of Barred Rocks and White Leghorns hatched in March, April and May for a period of six years:

TABLE IV.

Average Percentage Monthly Egg Production for 2,375 Barred Rock Pullets Hatched in March, April and May.

Month hatched	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Average Annual Production
March............	25.79	44.04	43.94	40.71	38.72	41.39	53.29	57.06	56.98	51.96	46.23	48.46	....	....	166.84
April.............	....	17.79	36.44	43.25	39.79	45.90	57.06	61.25	56.13	53.12	48.48	46.43	39.22	....	165.75
May..............	....	....	12.17	30.46	32.36	38.69	48.44	53.94	56.61	50.67	49.09	45.98	43.24	31.17	149.90

TABLE V. Average Percentage Monthly Egg Production for 1,312 White Leghorn Pullets Hatched in March, April and May.

Month hatched	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Average Annual Production
March............	20.80	40.48	35.81	35.43	35.59	40.34	47.93	43.66	54.43	55.62	45.19	40.15	....	....	150.67
April.............	....	14.68	42.17	38.05	35.86	40.42	46.41	44.63	59.90	56.22	46.14	39.48	30.97	....	150.52
May..............	....	....	18.66	37.32	44.64	47.12	52.59	51.97	61.66	54.65	46.77	44.52	42.67	26.65	160.96

In the following tables is given the average monthly egg production per bird for three groups of Barred Plymouth Rocks and three groups of Single Comb White Leghorns hatched in March, April and May.

TABLE VI. AVERAGE MONTHLY EGG PRODUCTION PER HEN FOR 2,375 BARRED ROCK PULLETS HATCHED IN MARCH, APRIL AND MAY.

Month hatched	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Average Annual Production
March	7.71	13.64	13.17	12.60	12.00	11.58	16.50	17.11	17.65	15.57	14.31	15.02	....	....	166.84
April	....	5.51	10.93	13.42	12.36	12.86	17.70	18.37	17.40	16.00	15.03	14.40	11.77	....	165.75
May	....	....	3.65	9.44	10.03	10.83	15.07	16.17	17.50	15.20	15.22	14.25	12.97	9.66	149.90

TABLE VII. AVERAGE MONTHLY EGG PRODUCTION FOR 1,312 WHITE LEGHORN PULLETS HATCHED IN MARCH, APRIL AND MAY.

Month hatched	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Average Annual Production
March	6.24	12.55	10.74	10.98	11.03	11.29	14..85	13.10	16.77	16.68	14.00	12.44	....	....	150..67
April	....	4.55	12.65	11.79	11.12	11.31	14..39	13.39	18.57	16.99	14.21	12.27	9.28	....	150..52
May	....	....	6.59	11.57	13.84	13.19	16..30	15.29	18.85	16.00	14.50	13.80	12.80	8.26	160..96

In the foregoing tables it will be noted that the average annual production is practically the same for different dates of hatching. It would, therefore, appear that so far as total production is concerned there is little to be gained by early hatching. If, however, the reader will compare the production figures

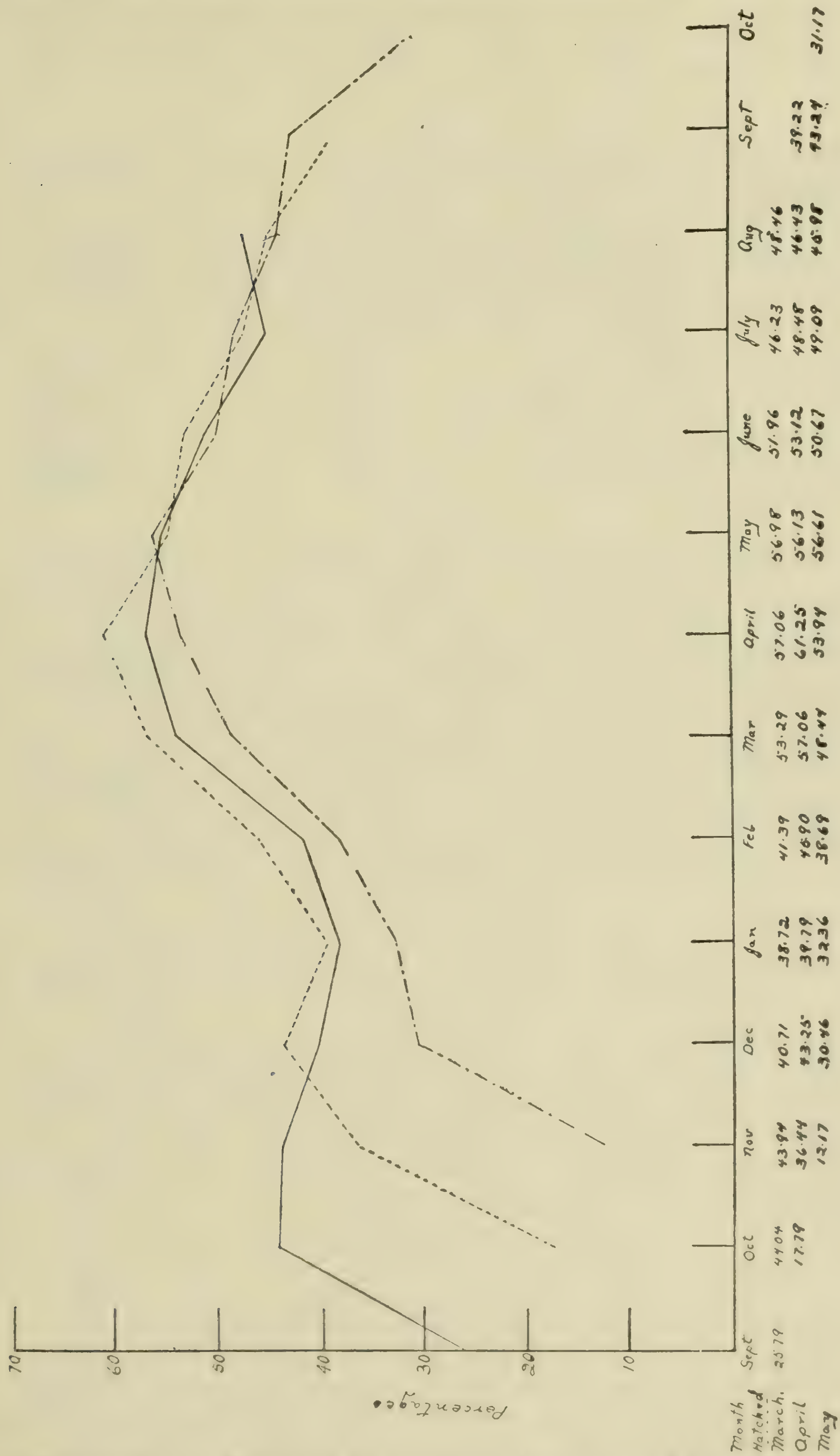


Fig. 15. Percentage Egg Production by months of three groups of Barred Rock Pullets hatched during the months of March, April and May.

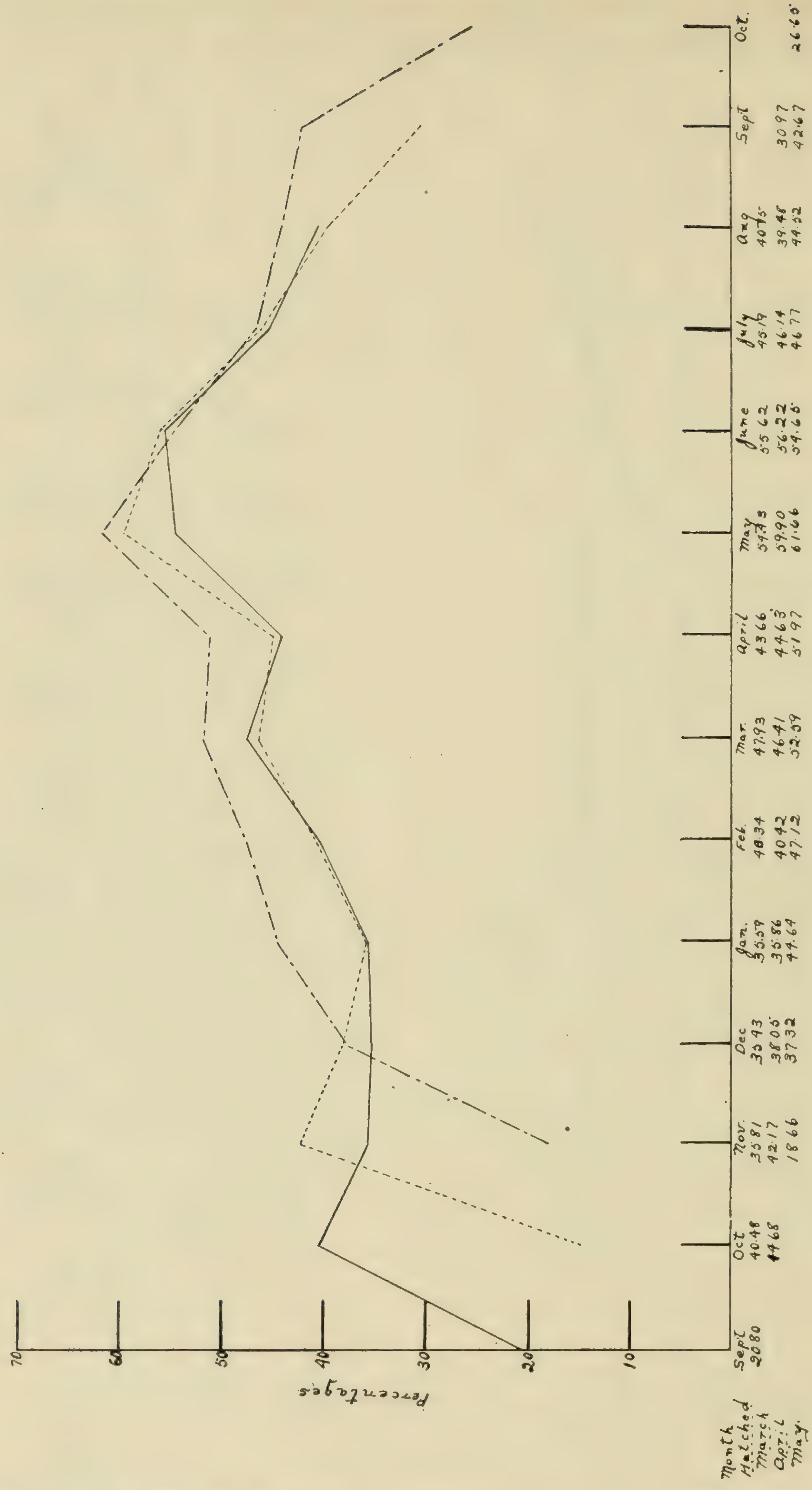


Fig. 16. Percentage of Egg Production by months of three groups of White Leghorn Pullets hatched during the months of March, April and May.

for the different months, and the different groups, he will find that the early hatched birds produced a moderately large number of eggs in the fall when prices were high, before the later hatched birds got started. This difference is very graphically shown in Figs. 15 and 16. There is the further advantage in early hatching, especially in early March hatched chicks, in that the cockerels can often be brought to broiler weight while the price for broilers is still good and the cockerels can be marketed, thus giving the pullets a better chance to develop.

Viewing the matter from the purely economic question of profitable egg production it is interesting to compare the values of the eggs produced by birds hatched during different periods, and on the basis of current market prices for eggs at country points during the period of production. Below is given the average monthly price of eggs per dozen at country points in Ontario for the period from October 1st, 1925, to September 30th, 1926.

October	47c.	April	29c.
November	55c.	May	29c.
December	65c.	June	30c.
January	44c.	July	29c.
February	36c.	August	34c.
March	32c.	September	43c.

On the basis of the above prices and the average monthly production figures given in Tables 6 and 7, it will be found that there is considerable variation in the total value for the year. The production figures would indicate that there would be very little difference in the value of the eggs produced by either breed hatched in March and April. The great difference is noticeable when comparing May hatched birds with either of the other groups. For example, in the Rocks the eggs from May hatched pullets were worth sixty cents per hen less than April hatched and seventy cents less than March. In the May Leghorns with their high comparative production one might expect their eggs would be worth more than the March or April group. We find that their eggs are worth twenty-five cents per hen more than either March or April group.

In presenting the foregoing figures it is not the intention that they be interpreted as possibilities of the two breeds, as the strain or selection work might show as great difference between strains of same breed.

These figures are given in the hope that they may suggest, particularly to the specialized poultryman, the necessity of carefully recording his daily, weekly, and monthly records of production costs and profits. The keeping of poultry as a specialized business means, if success is to be obtained, a daily or at least weekly record of the loss and profit statement. Success or failure depends much upon these accounts. Yearly statements usually show losses, leaks, etc., too late.

In other portions of the bulletin are discussed housing, feeding disease and so forth.

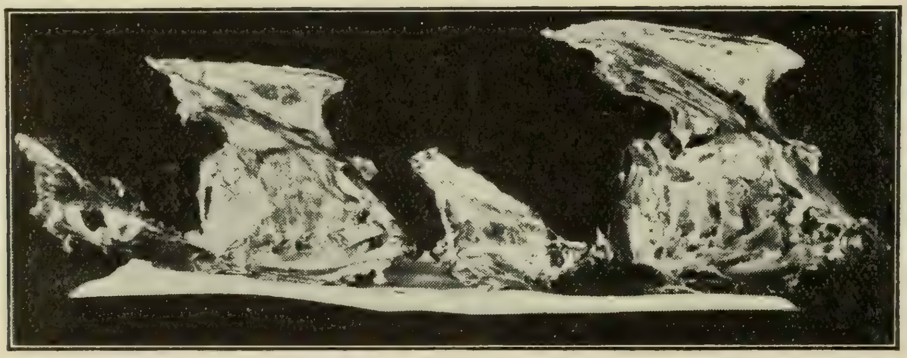
To sum up, in general, the requirements for high egg production are clean, dry, comfortable houses, that are free from direct draughts over the birds, and that are well lighted. The feeding consists of a variety of grains, green feed, animal feed, grit and shell, which is clean, sweet and wholesome, and is given to the birds regularly and in such quantities that they have all they want to eat before going to roost at night; that the supply of drinking material is clean and abundant; that the attendant is regular in his or her work and is interested in the same; that the birds are bred from good laying ancestors, and that they are hatched at the proper season and well reared, and are free from disease.

POULTRY CULLING.

WEEDING OUT THE BOARDERS.

As a result of close study by a number of investigators of different experiment stations it has now become possible to select the good layers from the poor by visual characteristics, and with a fair degree of accuracy. Neither is it the sole work of experts, as the average man or woman interested in poultry can very readily master the more important features of the work sufficiently to remove with ease and efficiency the poor hens of the flock. The fine details of the culling require a more extended period of study, but are not absolutely essential in the general application of the work.

Every farmer knows there is a great deal of difference in the type of his cows, and also that there is quite a noticeable correlation between the type and producing capacity of the individual. There are three distinct types of cattle, i.e., (a) Beef; (b) Dairy; (c) Dual Purpose. These types can readily be compared with corresponding types of poultry. There is the round bodied, loose feathered, sluggish type, which fattens readily and lays but few eggs. We also have the flat sided, deep bodied, more closely feathered, clean cut, angular, alert hen, which fattens slowly and performs well as a producer of eggs. We also have the intermediate types which show certain characteristics common to the two former types, but not developed to as marked a degree as either of the former, and whose production is in direct correlation to its similarity to either of the former distinct types. The accompanying illustration, Fig. 17, will show the difference in body type in the skeletons of high and low producing individuals. The outstanding difference in body type are easily noticed here. The deep flat side, with ample capacity for strong, well developed organs of digestion, circulation, respiration and production, is easily seen in the high producing hen. Note the long keel running parallel or tending to slope upward in the high producing hen as compared with the shallow body resulting in lack of capacity in the poor layer.



Low capacity. High capacity.

Fig. 17. Note the great depth in the skeleton of the high class hen.

The type as indicated by these skeletons must be recognized in the flock, and those not conforming weeded out. We will first consider type as noticed in the coop or in the yard. In general, the hen must be rectangular in shape when viewed from the side. She must carry a good length of rib, giving her the appearance of being deep from back to point of breast. The back should be long and fairly level, with a corresponding depth behind. In studying type as seen in the run notice feathering. Loose, fluffy feathering will camouflage real body type, and as a rule close feathering goes with good type. The abdomen should not be over-fat and sagging, but should be carried up well and supported by the keel. The illustrations show very well the desirable body type. Note the great depth and strength of constitution in Hens Nos. H69-K182-H7-K67-H19-L60-K1801-K186-G29, pages 15-16-17.

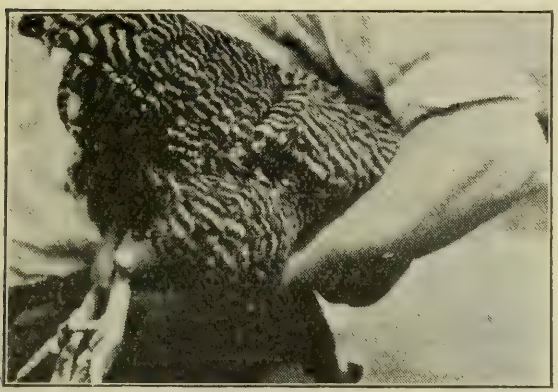


Fig. 18. Method of holding bird.

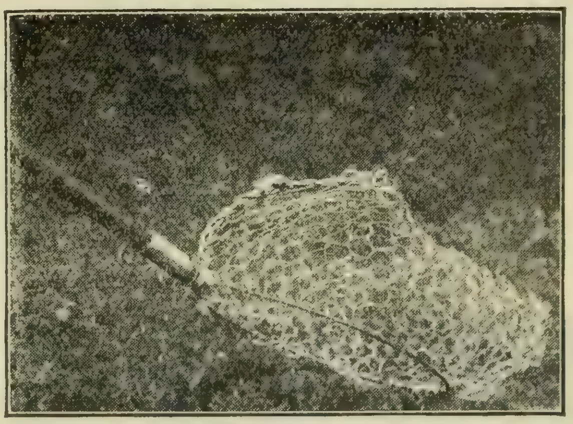


Fig. 19. Catching net.

HOW TO HOLD AND HANDLE BIRDS IN CULLING.

The amateur poultryman often experiences considerable inconvenience in handling birds, and just as often causes the bird much worry while handling. Fig. No. 18 shows the proper way to hold a bird. The hen when held on the arm in this way, with the keel bone resting on the arm, the first finger between the hocks and the thumb and second finger used to grasp the upper shank, will rest quietly and give one a chance to examine the various points to be considered.

If the birds are culled at night they can be easily taken off the roost and handled and separated. If, however, the birds are handled in daylight and are just closed in a pen, a catching net, as illustrated, Fig. 19, is a great aid in catching the hens. One can easily be made from a piece of heavy wire, some wire netting, and an old hoe or broom handle. When the birds are caught they can be handled and the following points studied and considered:

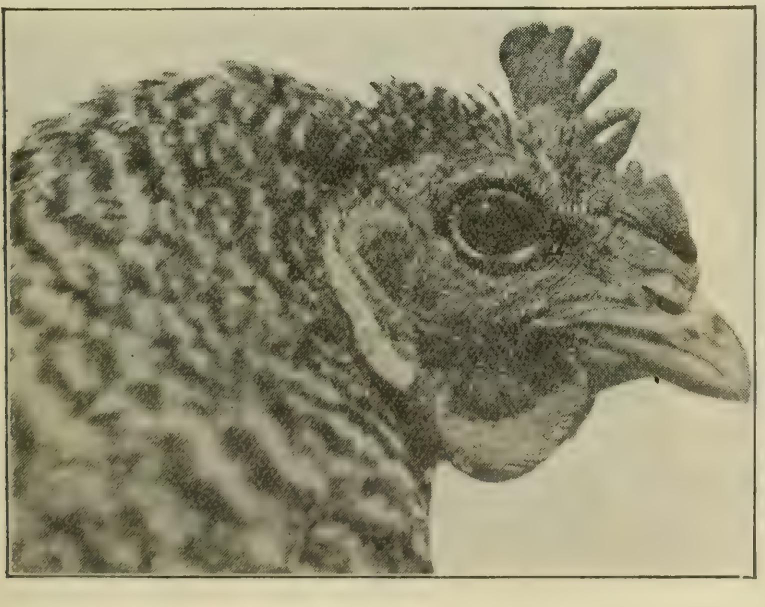


Fig. 20. Side view of good head.

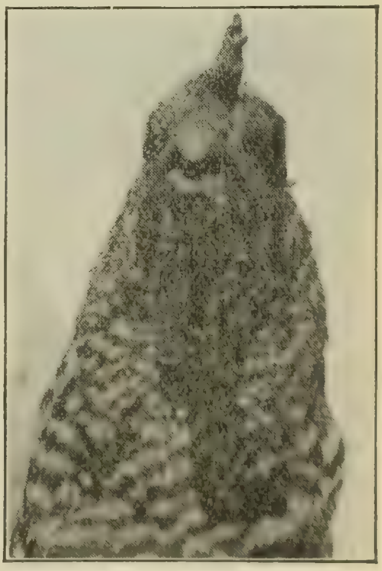


Fig. 21. Front view of good head.

Head Types. The head tells an interesting story. It is an index as to what may be expected in the body type and performance of the hen. The head should be clean cut, medium size, not too long or crow-headed, nor too short and bunty. The crow-headed type is an indication of low producing ability, and often of lack of constitution. The short beefy head indicates a sluggish type and is often correlated with a predisposed tendency to fatten, and a small egg production.

The illustrations show several interesting features in heads. Figs. Nos. 20 and 21 show heads with abundance of character. Note the well turned beak, fine texture of skin about the face, the bright prominent eye well back in an eye socket showing white membrane in front, the absence of wrinkles or beefiness over the eye and about the face. The comb is waxy and bright. These heads have vigour, action, and "pep" sticking out all over them.

Compare these heads with Nos. 22 and 23. Here we find the long pointed beak, dull comb, or the type with wrinkles of fat over the eye and the coarse skin about the face. The dull, sluggish eye set in a close round eye socket does not show the life and character the other heads exhibit so plainly. No. 24 is a typical broody head. By passing the finger carefully along over the head from the rear of the beak and just over the eye to the side of the comb a distinct bump can be felt. This in the craniology of the hen is her broody bump and indicates a predisposition to exercise her maternal franchise instead of staying steadily in the world of production. Note the absence of this prominence

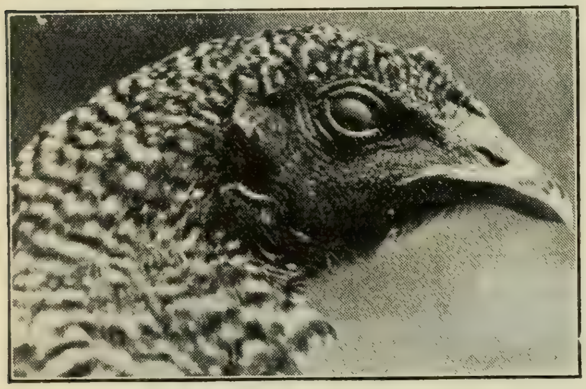


Fig. 22. Side view of poor head. (Crow head.)

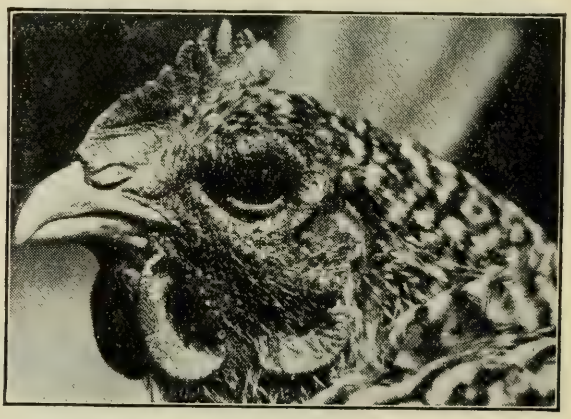


Fig. 23. Side view of poor head. (Fat head.)

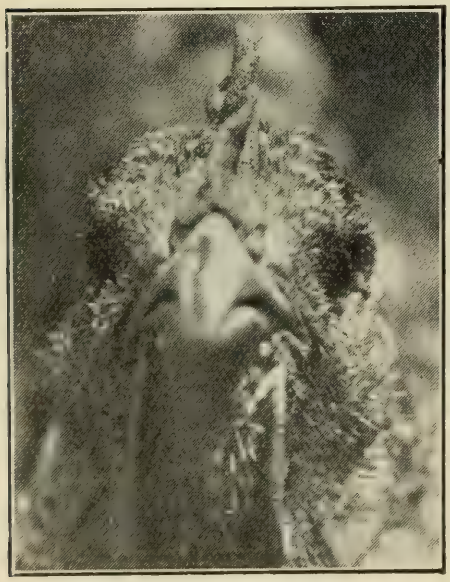


Fig. 24. Broody head.

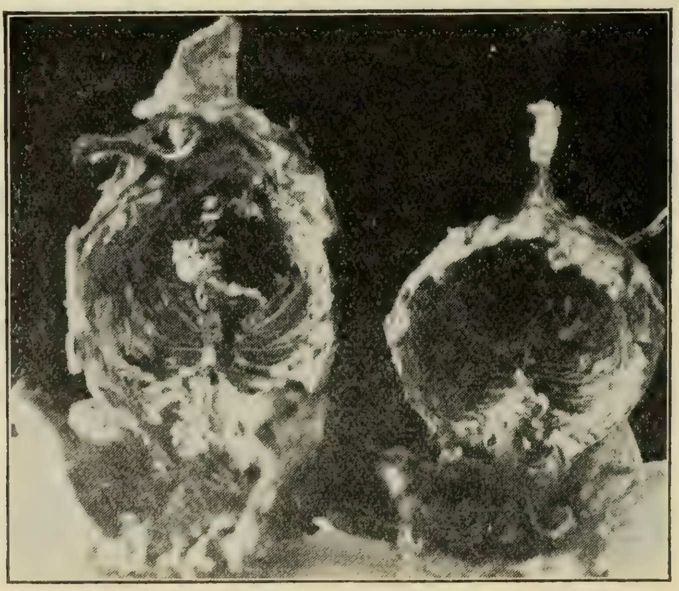


Fig. 25. Rear view of skeletons.

in the heads of heavy layers. There is a danger of going to extremes in head types, and the hen with the extremely fine or delicate head is apt to lack vigour and may not stand up against heavy production. This type, however, is rather rare and the fault is not as common as the heavy, broody head.

Body Conformation. The head has set you wondering what type of body the hen is likely to have. The type can easily be ascertained by handling. Holding the bird as described above, take the other hand and put the thumb over the back just under the wing and let the fingers fall along the side of the bird to determine the length and spring of rib. This is the part of the hen which might be compared to the motor of an automobile. Here all her vital organs, as the heart, lungs and digestive organs, must operate and produce eggs and build up body waste to stand the wear and tear of heavy production. If the hen is to develop speed as a layer her motor must be large and powerful, and it must have room to operate. Thus we find that the hen must possess good spring of rib and a deep, flat side. Fig. 25 shows the difference in spring of rib in high producing hens and in low producers. Note the long flat side on the high producer and the round well-sprung side on the lower producer. This can be determined by handling as described above.

The back should be of good length with good width carried well out from hips to pelvic bones. Note Figs. 26 and 27.

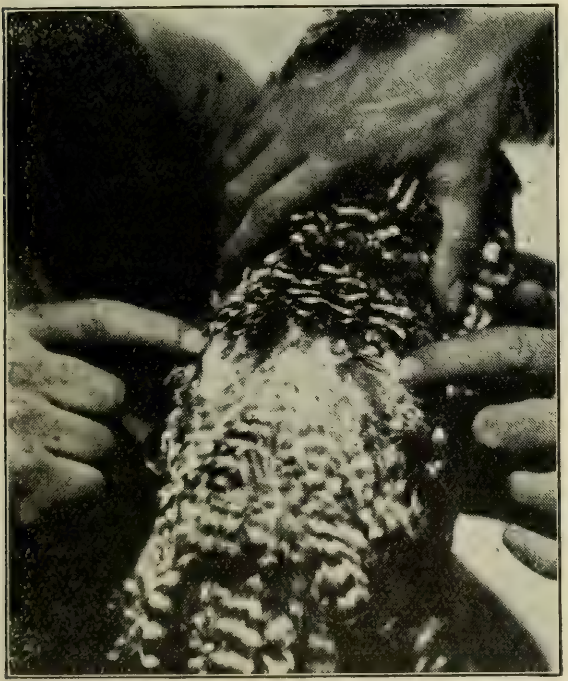


Fig. 26. Broad flat back carrying its width to the tail.

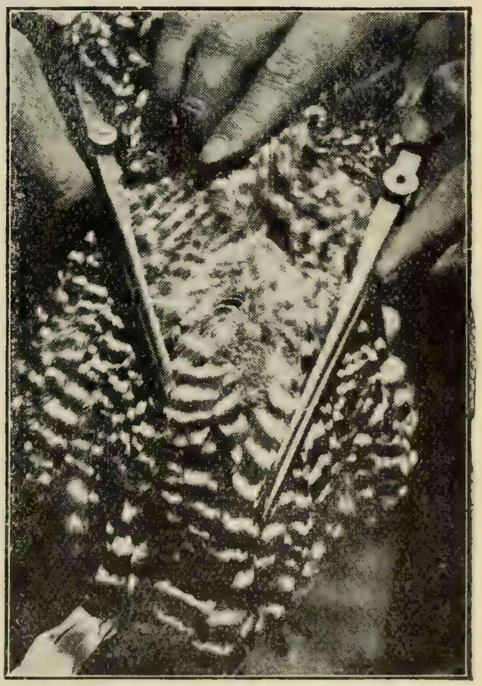


Fig. 27. Rounded back forming a wedge with the tail. Poor type.

The shape of the keel bone is important. It should run back either parallel with the back or sloping down. It must be long to support the abdomen or egg sack. In high producers the keel frequently has a decided hook or turn down at the end. This is a good feature, and while not always found is generally a sign of early and persistent production in pullet year. This conformation of keel bone is what goes to make capacity in the egg sack. The undesirable type of keel is one which has a decided upward direction towards the vent, and such birds are often described as being canoe keeled.

In order to determine the capacity of the egg sack the hand can be placed at the rear of the bird as shown in Fig. 28. The lower finger can readily find the position of the end of the keel and the first finger the position of the pelvic bones. These pelvics are two thin bones projecting out one on each side of the vent and just above it. The measure of the distance from these bones to the end of the keel is called the capacity and is spoken of in terms of the number of fingers one is able to insert. Fig. 29 shows a poor producer with a canoe keel and only two fingers capacity Compare this with the hen shown in Fig. 28 having more than four fingers capacity and note the relation of this capacity to the production of the birds.

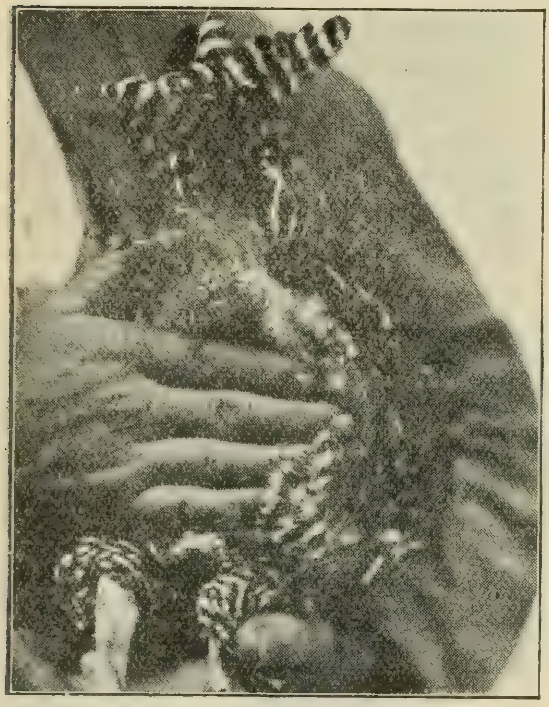


Fig. 28. Good capacity—292 eggs.

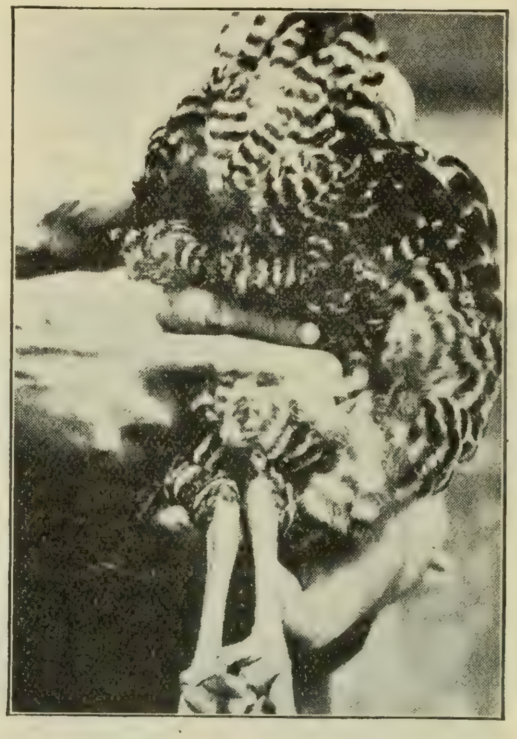


Fig. 29. Poor capacity—84 eggs.

The capacity of a hen is not always the same. If the ovary is dormant and no eggs are being manufactured the capacity will be rather small. However, as soon as ovulation commences the distance between the pelvic bones and the keel begins to increase and in full ovulation, or at a hen's highest production, the capacity of the bird will be the greatest.

Any one who has dressed hens will have noticed the large accumulation of fat in the abdomen of some birds. This accumulation can be determined while the hen is living by handling the flesh in the egg sack. The fat if present will be hard and firm. This is a sign that ovulation has ceased and that the hen is now using her feed supply to lay up fat instead of producing eggs. If a hen has accumulated a quantity of hard fat in the abdomen it is almost a sure criterion that the hen's laying days are about spent, and it is time that her day's work in the flock was done and she should be sent to market.

Handling Qualities. This term refers chiefly to the quality of the skin in the egg sack. As noted above there should be no hard fat. The skin should be soft, pliable and elastic to the touch. It should not have a tough, hard nor leathery feel. This quality of the skin is closely related to the quality of the skin about the face of the bird. The coarse texture can be readily noticed in the face and is found to carry throughout. It is a sure sign of a lack of quality.

Shanks and Toes. Quality in shanks is indicated in much the same way as in good horses. The bone should be flat, not too fine, but smoothly scaled.

A poor quality of bone is round, hard and roughly scaled. The toe nails carry the index to the amount of scratching the hen is doing. A good layer is always a good worker and her toe nails will be well worn down from scratching. This will vary with the kind of pen the hen is in. A concrete floor will wear the toe nails much faster than a wood or earth floor. This feature, therefore, must be compared with other birds on the same or a similar floor.

The colour changes in the shanks are important and will be described later.

Condition. A hen will not lay if not in good condition. She should be healthy, free from any disease, and show plenty of vigour and activity. The first pullet to lay in the fall is the early maturing one. The hen which is a slow grower, is slow in feathering out, is also a slow layer. The moult is important. As soon as a hen goes into a moult she uses her feed to manufacture feathers, and her egg production falls generally to a minimum of nothing. It is easily noticed that some hens go into a moult much earlier than others. If a hen starts to moult in July her laying for the summer is about over. So we say that late moulting and heavy egg production go together, because it gives the hen a longer summer period and still she is back in form in time for winter production.

Plumage. If a hen is laying heavily the plumage will become dry, hard and brittle. The lustre will disappear and the feathers become broken. The hen certainly loses much of her natural beauty, but she cannot retain that bright lustre and also keep up heavy production. Watch for the old lady with the full array of feathers all in good form, and see if she is not one of the boarders in your flock.

When is a hen laying? The question is often asked, "Can you tell whether or not a hen is laying?" This is very easy, and requires but a few observations. When a hen commences laying the conditions set up in the reproductive organs are very similar to conditions in any pregnant animal. Preparation is made for laying, much as for parturition in a cow.

When the ovary is dormant and no eggs are being produced the distance between the pelvic bones is very small. The vent is dry, small, puckered, and in yellow fleshed birds has a decided band of yellow pigment around the inside. When laying commences the pelvic bones become pliable and spread apart. The distance may increase from one to three fingers in a short time. The vent becomes large and moist and after two or three eggs have been laid the ring of yellow pigment has disappeared and the vent is bleached.

Further Colour Changes. There is an interesting study in pigment changes. This refers only to yellow fleshed birds and cannot be determined in white fleshed birds, as Orpingtons.

As mentioned above, the first change in pigmentation is in the yellow ring just around the vent. Two or three eggs will remove this colour. The colour then leaves the eye ring, the flesh just around the edge of the eyelid. It usually requires about six eggs to remove the yellow colour from this part. After the sixth egg the colour starts to leave the beak, commencing at the rear of the bill, and fades out white. There is quite a distinct line of demarcation between the yellow area and the white. As laying proceeds the white area increases, gradually crowding the yellow out toward the end of the beak. When the colour is entirely gone from the beak the hen will have laid about thirty eggs. The shanks are the next part affected. After the colour has left the beak it starts down the front of the shank, the white area again appearing and the yellow receding down the front of the shanks and from the foot up the back, the last trace of yellow being on the back of the hock. It requires about one hundred and fifty eggs to remove the colour entirely from the shanks. There is a difference in the rate at which this colour will leave. Feeding plenty of green feed tends to produce the yellow colour and to prevent its disappearance. Birds in confined quarters in winter show the colour changes more plainly than birds on range in summer where they are receiving abundant green feed.

When the hen ceases laying the colour at once commences to come back. This change can be readily studied in a hen which has gone broody and is raising chicks. The colour first returns to the vent, then to the eye ring. A yellow area now proceeds out the beak in the same way the white area did previously, and is followed by similar changes in the shanks. From a study of these changes one must view with suspicion the hen that parades about the plant with her full quota of yellow colour. Short rest periods, as broody periods, often result in a band of yellow in the beak preceded and followed by a band of white showing that during the time it took for the hen to be broken up she replaced some yellow pigment which again was followed by bleaching when laying recommenced.

Signs of Broody Disposition. In studying heads we went into some detail in the broody type of head but will not enlarge upon it here. However, since

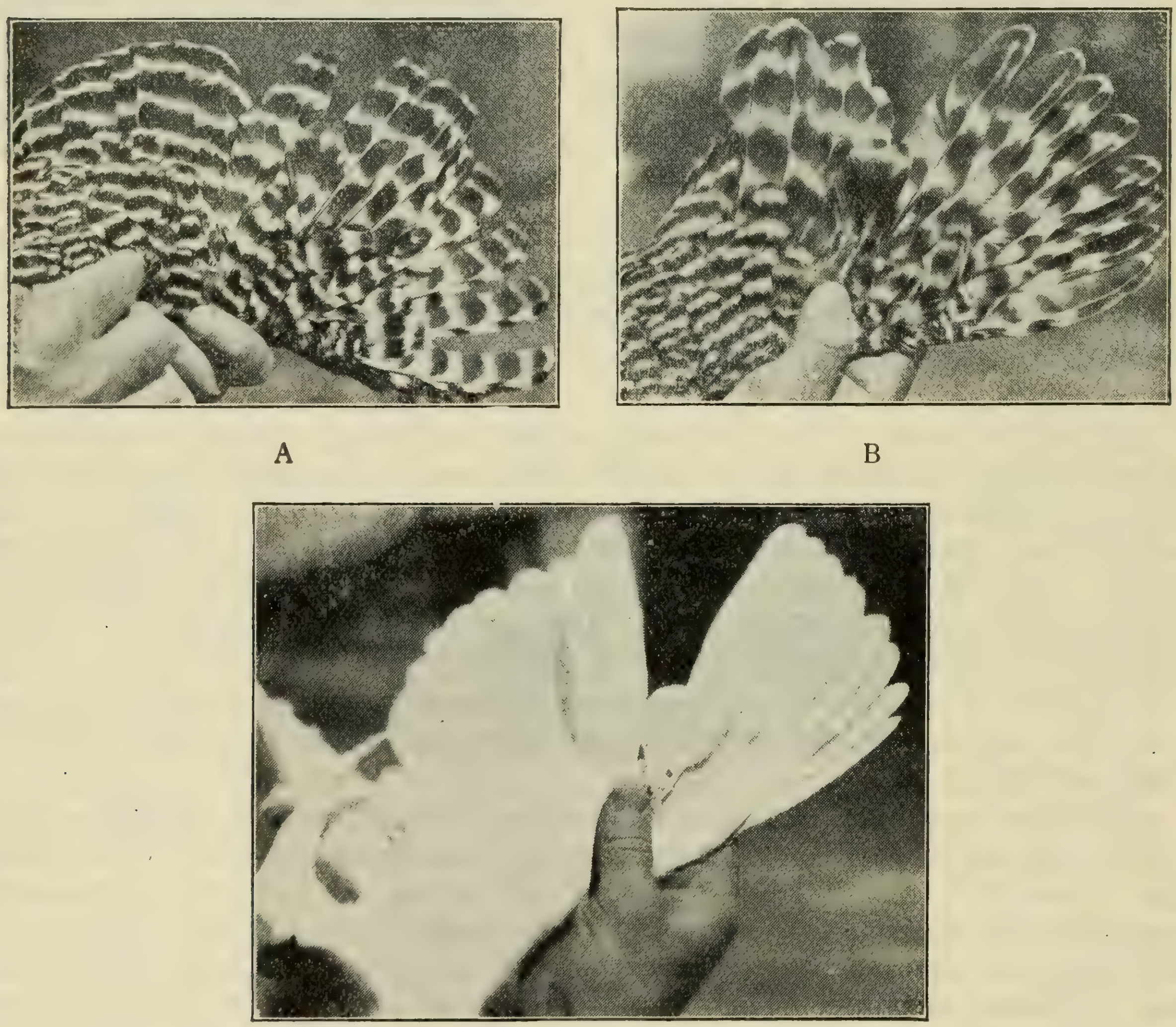


Fig. 30. Wing moult.

A—First primary moulted and in, second primary moulted and partly grown.
B—A pair moulted at same time, one broody period.
C—A duplicate of "A."

a hen loses from ten to fourteen days every time she goes broody the habit if present will soon reduce her egg record, especially if she goes broody more than twice a season. Fig. 30 shows wings outspread. The flight feathers are divided into two sections, Primary, and Secondary. When the hen goes broody in the summer she frequently moults a feather in the primaries. This moult commences next to the small axillary feather at the division of the wing. The first time broody the hen may moult No. 1 and a new feather will grow in. At each succeeding period of broodiness another feather may be moulted and a new one will take its place. In the illustration the hens have had rest periods as shown by the new feathers. The complete section of primaries contains nine or ten feathers, so by counting these and taking note of any new feathers growing in, the number of times a hen has been resting can be determined. A hen showing a tendency to spend much of her time in brooding can well be removed from the flock as her production will not be high.

Disposition of the Laying Hen. There is as much difference in a hen's manners as there is in the manners of the human race. Almost invariably the heavy layer is quite docile and does not object to handling. She will rest quietly in your hands and sing quietly all the time she is being handled. The cull has a disposition quite in keeping with her head type. She is noisy, wild, and the quiet singing of the good hen is replaced by squawking of the cull. This same difference can be noticed in the birds about the pens. The heavy layer is always going about busy but contented. She is first off the roost in the morning and last on at night. She picks few quarrels, has no desire to join a labour union or to demand six hour days. Her work commences at daybreak and continues relentlessly but cheerfully until often sundown. She spends little daylight on the roost with her less ambitious neighbours.

The Time to Cull Hens. There has been some difference of opinion as to the proper time to cull flocks. Culls are a liability, and should be put on the market early enough to get as good a price as possible, so we recommend getting into the flock in the latter part of May or early June. At this time of the year the heavy spring production is over and the naturally disinclined members of the flock will be soon quitting, and the price received for hens is still good. The flock may be culled at any time, however, and the careful poultry husbandman will always keep close watch on his flock for any outstanding boarders. In late July and August the early moulters should be watched and marked and disposed of.

Marking the Culls. In culling, the hens can easily be graded into three classes and marked.

(a) The good performer can be banded and left in the pen.

(b) The ones which are real culls should be crated and sold.

(c) There are, however, a number of hens which are still laying but which are of poor type and will not be desirable members to hold over. These can be marked temporarily and kept until they have ceased laying and then sold. A good method of marking these birds is to cut off their tails. This makes them easily picked out later, and a second trial will often convict many of them.

POULTRY HOUSES.

The poultry house or pen is essentially an important factor in determining success or failure in the poultry business. Type of house is not so important, as we find poultry thriving and yielding good returns from houses which are distinctly different in type. It is, therefore, difficult to lay down any hard and fast rule relative to type.

There are two general classes of poultry houses: laying, or breeding houses, and colony, or rearing houses. The former are built upon permanent foundations while the latter are mostly portable. Most of the general principles of house construction apply in both classes of houses, the chief difference being in size of house and type of foundation. However, as the laying or permanent houses are more important they will be discussed first.

Location of Houses.

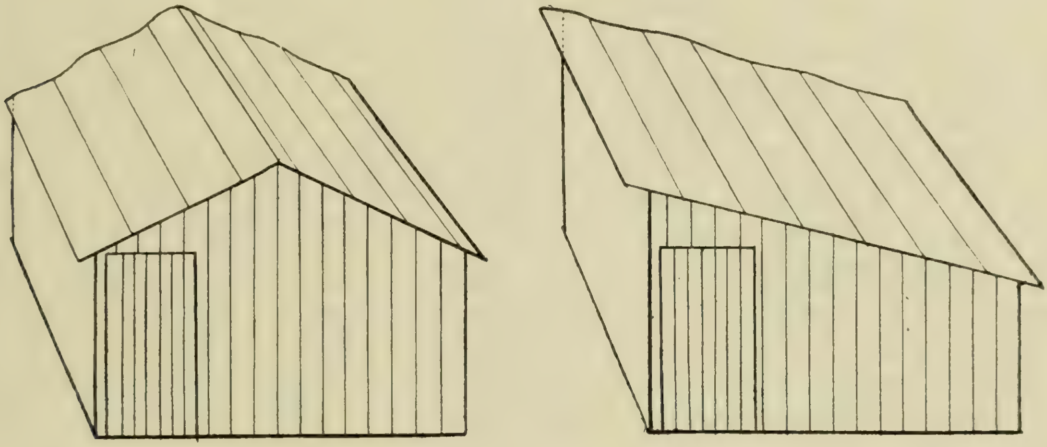
Near to the Source of Supply. Whether the number of birds to be kept is large or small there will be a considerable amount of feed to transport, and hence the nearer to the source of supply, with due consideration to other equally important factors, the greater will be the saving in time and labour.

Exposure. The house should be built facing the south or south-east if possible, as such an exposure will give the maximum amount of sunlight in the pens. There is also greater protection from the prevailing winds which are from the north or north-west. Full advantage should be taken of any shelter (either natural or artificial) from the prevailing wind, as the birds do not take kindly to an exposed location. Bird comfort is closely associated with economic production, and any condition which can be made use of in making the bird more comfortable should receive full consideration.

Drainage. Drainage about the poultry house and yards is of extreme importance. Poorly drained yards aggravate the trouble from dampness in the houses and yards. There is also a manifestly increased amount of trouble from diseases and intestinal parasitic infestation, under such conditions. The type of soil and the lay of the land are influencing factors in drainage. The ideal soil condition is a soil which is slightly rolling and open in texture, so that the surface drains off readily after rains or melting snow. Heavy soils at best drain poorly and are hence most unsatisfactory.

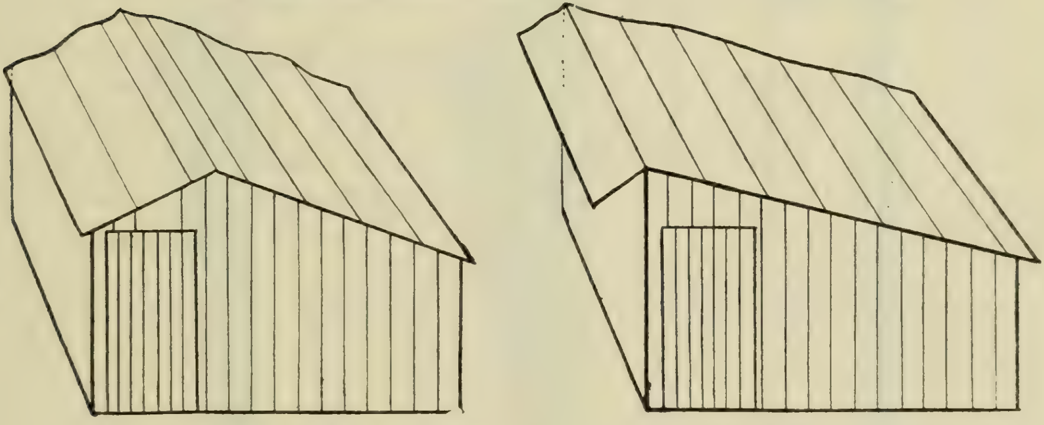
Types of Houses. There are two main types of laying houses in general use, i.e., the long or continuous house divided into two or more pens, and the single pen house. There are many points in favour of each type as well as numerous objections to either. The long house is no doubt more economical to construct and requires less labour to operate. If separate matings are necessary, yards are required, which means added expense and close confinement for the birds. This latter point is important where using the birds for breeding purposes. The single pen house, while costing more than the continuous type, permits of spreading the birds over a larger area, making it possible to dispense with yards, and less trouble is likely to be experienced with disease and loss of vigour in the flock. The greatest objection to this latter method of housing is the extra labour required to care for the stock.

Types of Roofs. There are three principal types of roof construction commonly used in Ontario. These are shown in Fig. 31. It is true there are other types used, but the three mentioned are the best suited to Ontario winter conditions. There is some slight difference in the cost of the types shown. The shed or shanty type is no doubt the cheapest to construct. It does not permit of the use of the straw loft which is so important in assisting in the control of moisture in the house in the winter and keeping the house cool in the summer. The gable roof is best adapted to the use of the straw loft, and besides presents a more attractive appearance, blending better with the general type of buildings on the farm. Perhaps the greatest objection to the shed roof is the extreme heat of the building in the summer, the temperature at times registering as high as 110° F. This may be overcome to some extent by using the hood on the front with the rear ventilator opening. This will, of course, increase the cost of the building to practically the same point as the gable roof.



Gable Roof

Shed Roof



1/3 - 2/3 Roof

Shed Roof with Hood

Fig. 31. Roof types.

Floors. Floors in poultry houses should be made of concrete. While board floors and dirt floors are used they are not satisfactory. A good board floor will cost almost as much as cement, and is not nearly so durable or sanitary, while a dirt floor is objectionable because of the dust, and rats and mice. As the chief essentials in a good floor are dryness and ease of cleaning, it is advisable to have the floor-level raised about eight inches above the ground-level at the highest point, and the top surface finished as smooth as possible to facilitate cleaning.

The essentials of a poultry house may be stated as follows: (1) The house must be comfortable; (2) free from direct draughts; (3) dry; (4) light; (5) not overcrowded; (6) well ventilated.

Egg production is the primary object in keeping hens, and their housing conditions play a very important part in determining success or failure. Only by observing the factors essential to successful housing and properly balancing these will the operator be able to make the business profitable.

Ventilation. It is necessary to ventilate in order to secure dryness, pure air, and a proper temperature. Bad ventilation is indicated by frost on walls or ceiling, and a foul atmosphere. A greater amount of moisture pound for pound live weight is exhaled from the lungs of birds than of any other class of stock. The ventilating system must remove this moisture from the pen, provide fresh air and do so without producing draughts in the house. Cotton curtains, window shutters, and open-front houses are now most generally used, with the cotton curtain in conjunction with or without the straw loft proving most popular. Curtains must be adjusted from time to time to meet varying weather conditions, and unless one is prepared to do this better results will no doubt be secured from the use of the open-front house. This latter type is illustrated in Fig. 36, and will be found satisfactory in any part of Ontario as far north as Lake Simcoe.

In Fig. 32 is shown a cut of a window adjusted for ventilation purposes. The window is six inches from the ceiling and eighteen inches from the floor. It is hinged from the bottom, and the opening at the top is adjusted with a cord. Burlap or boards may be placed along the sides of the open window.

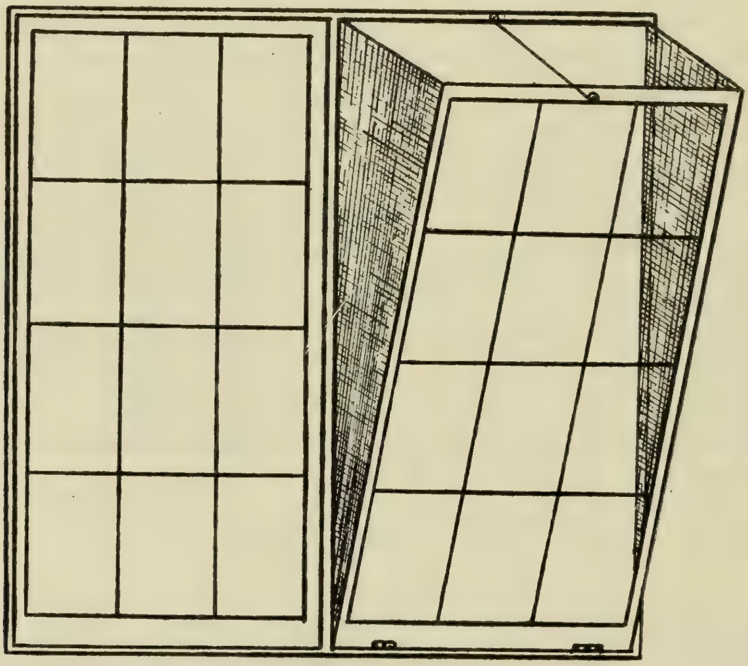


Fig. 32 Window arranged for ventilation purposes.

A low-grade open burlap should be used. This device does not interfere with the light, is not attended with draughts, and gives good ventilation. It is suitable for the alteration of some house now in use which is not at present giving satisfactory ventilation. The alteration can be made at a very small cost, and may be preferred by some to curtains.

Draughts. There is perhaps no condition in the poultry house which is responsible for more trouble and mortality than draughts. This is particularly true if the birds are in a draught while on the roost or while working on the floor. Draughts chill the birds, making them uncomfortable, and, therefore, unproductive, and also produce disease such as colds, roup, rheumatism and kindred ailments in the flock, resulting in heavy mortality. In constructing the house every effort should be made to eliminate draughts, especially those which will strike the birds directly. The sides and back of the house should be absolutely tight and with ventilation from an open front, or curtains, little difficulty will be experienced.

Dryness. There are two sources of dampness in the poultry house. As previously stated, a large amount of moisture is exhaled from the lungs of the birds. Moisture sometimes enters the house through a badly-constructed floor or because of a damp location. It matters not from what source the moisture comes, if allowed to accumulate in the pen it will gradually lower the vitality of the stock, production will decrease, and disease will develop. The trouble is usually more marked in the fall and winter than during other seasons of the year. Where the moisture is not entering the house through the floor the trouble will be found associated with lack of ventilation. This latter is most clearly indicated during the winter months by the accumulation of frost on the inside of the pen. Where this condition exists the ventilation of the pen ought to be carefully gone over. It is no doubt true that damp houses are responsible in part at least for the prevalence of tubercular trouble in many Ontario flocks.

Sunlight. Sunlight is the best germicidal agent in existence. It is, therefore, advisable to make provision for the admission of as much sunlight into the pen as possible. This is especially important in the winter, and glass windows should be so placed in the front of the house as to admit a maximum of sunlight. One-quarter to one-third of the front of the house should be glass. Rectangular windows placed in an upright position will give best results as the sun's rays will then cover greater depth on the floor of the pen and as the sun travels around to the west during the day, practically the entire floor will be swept by the sun's rays. This would be possible if the windows were placed on the side.

The value of direct sunlight in the hen house is now becoming more and more appreciated from the standpoint of its effect upon the general health of the birds in the winter, also upon the hatchability of the eggs. This action of the direct sunshine is due to the ultra violet rays which are filtered out as the sunlight passes through ordinary window glass. Glass substitutes have been developed which are claimed will admit ultra violet rays. Some of these have been tested with satisfactory results, so far as admitting the passage of ultra violet rays, but the economic value from a durability standpoint has yet to be demonstrated.

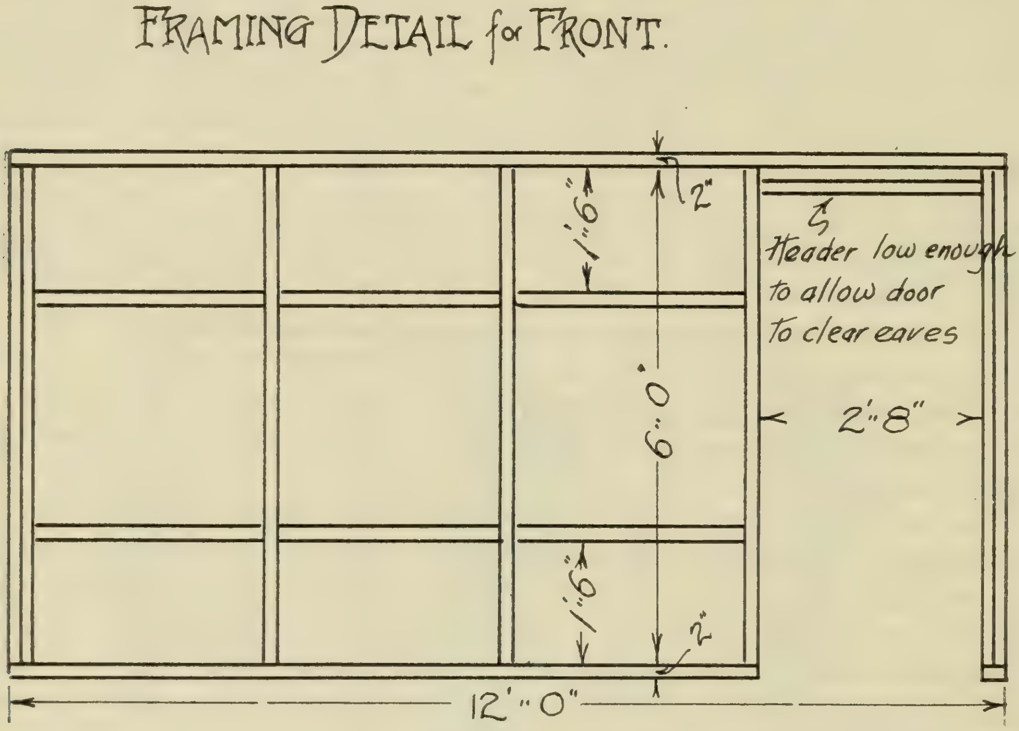
Sanitation. Birds that are not healthy will not lay. The houses must be kept in a clean sanitary condition. This requires close attention to the removal of droppings, frequent change of litter, and the proper ventilation of the house. In order to facilitate this very important work the plan and arrangement of the various fittings should be as simple in design and as convenient in arrangement as possible. Unessential fixtures simply add to the cost of the equipment, increase the labour of caring for the stock, do not add any productive value to the layout, and will be found generally a nuisance.

College Poultry Houses.

For a number of years we have been trying various styles of houses. The first houses constructed were well built, tight and warm. They were fitted with stoves or hot-water pipes, so that the fowls could be kept at a comfortable temperature. This plan was not satisfactory, mainly for the reason that it was difficult to keep the fowls in good health, and furthermore, the eggs were low in hatching power. The cost of heating was considerable; in fact, the entire equipment was too expensive to be successful as a business.

It was noticed yearly that the surplus stock held in the cheap houses was much healthier than those fowls kept in warm houses. During the past thirty years we have been trying to evolve a house that could be cheaply constructed, that would keep the fowls in good health, and at the same time get a fair egg yield from the fowls so housed.

With the increasing interest in poultry house construction, throughout the country, and with the object of standardizing house construction, we are presenting a type which lends itself to a variety of measurements. The plans, as presented, show two houses, one twelve feet in depth from front to back,


FRAMING DETAIL for FRONT.
1'6"
2"
Header low enough to allow door to clear eaves
6'0"
2'8"
1'6"
2"
12'"0"

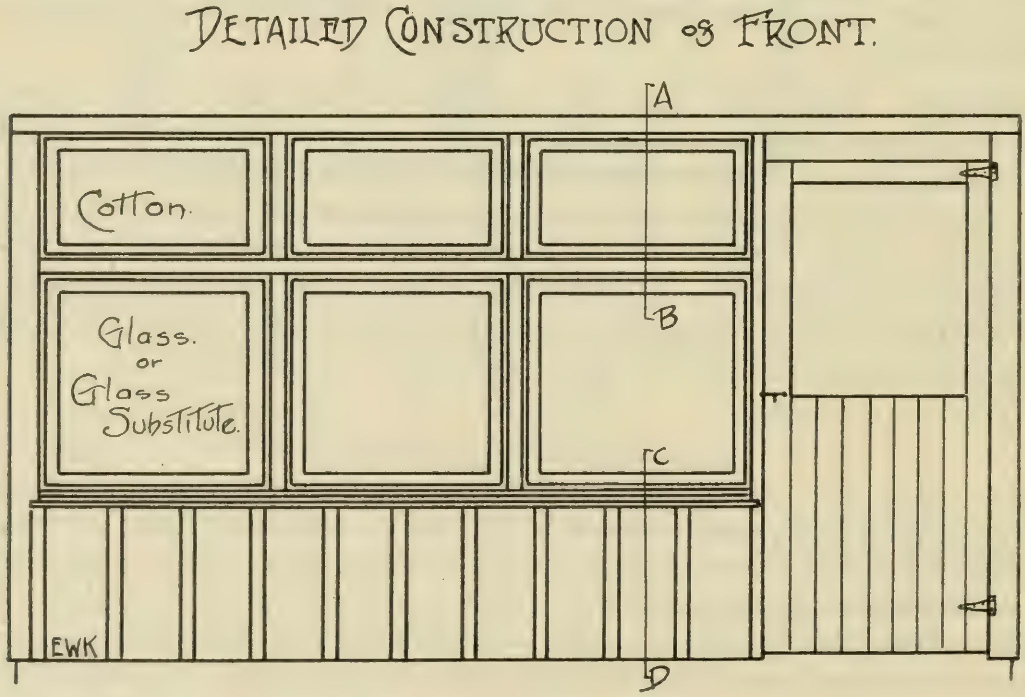


Fig. 34 (*a*) and 34 (*b*). Plan of house twelve feet in depth which may be fitted with either straw or cotton loft. It may be built one pen or several pens in length as desired.

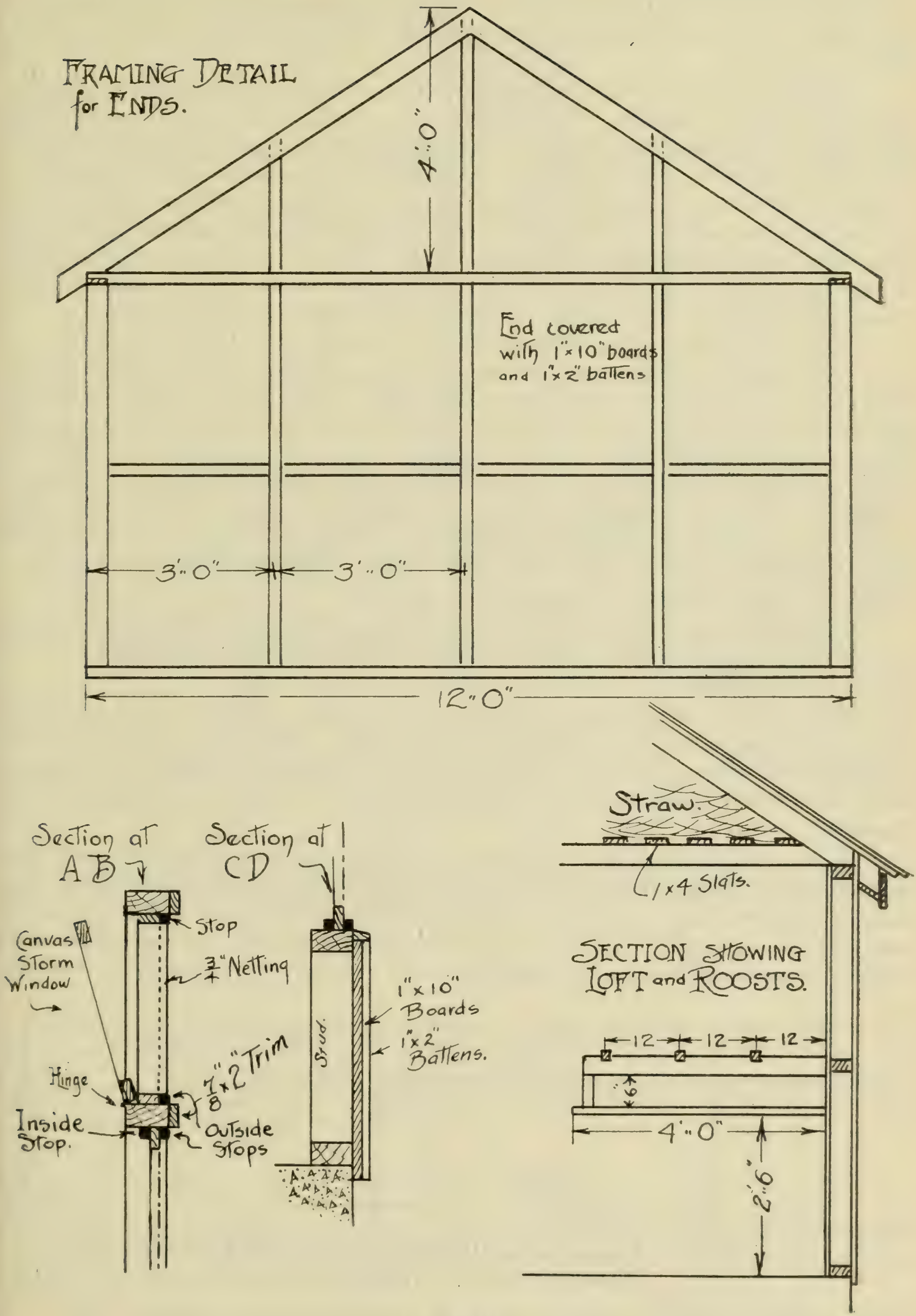

FRAMING DETAIL for ENDS.
4'-0"
End covered with 1"×10" boards and 1"×2" battens
3'-0"
3'-0"
12'-0"
Section at AB
Section at CD
Canvas Storm Window
Stop
3/4" Netting
7/8"×2" Trim
Hinge
Inside Stop.
Outside Stops
Stud
1"×10" Boards
1"×2" Battens.
Straw.
1×4 Slats.
SECTION SHOWING LOFT and ROOSTS.
12
12
12
6"
4'-0"
2'-6"

Fig. 34 (*b*)

and twelve-foot pens; while the other is twenty feet in depth from front to back, and twenty-foot pens. Either of these houses may be built with any number of pens desired, but maintaining the arrangement and type of construction as shown for the one pen.

The plan of construction of the front of these houses is practically identical. The lower section of the front is boarded. Above this is a row of windows extending across the entire front. These are fitted either with glass or glass substitutes. In the case of the latter, no sash are required, as the substitute is attached to a frame as would be done with cotton. Above the glass windows are a row of cotton curtains which are hinged at the bottom, tipping inwards at the top. The plans show doors entering the pens from the front, or a door may be placed at one end of the house, and partition doors in line, which would permit passing from one pen to the next without going out of doors.

Fig. 33. (See front cover.) House for which plans are shown in Figures 34 and 36.

Two kinds of ceiling construction are shown and these are interchangeable. The straw loft has been extensively used in the past and with good results. It assists in the ventilation of the pen, and thus reduces the trouble from dampness. Some people object to the straw as being dirty and a harbouring place for vermin. Such trouble seldom becomes serious, but in order to meet this objection a ceiling of cotton has been tried out and with very satisfactory results. The cotton is stretched on frames covering the ceiling and while the first cost is slightly higher than the straw loft, the cotton ceiling is white which gives a brighter, more pleasant appearance to the pen.

The roof of both houses is of the gable type. This allows for more effective use of the loft idea, which provides a warmer house in the winter and a cooler house in the summer.

The capacity of the pens presented is important. While the floor space of the smaller pen is over one-third that of the larger, the housing capacity of the smaller pen is actually one-quarter of the larger. The smaller pen will accommodate twenty-five birds while the 20 by 20 pen will readily accommodate one hundred.

In the operation of these houses, as is the case in any house fitted with adjustable curtains or screens, in order to work satisfactorily under all weather conditions, it requires the constant attention of the operator. In dull heavy humid weather, the adjustment of the curtains would be somewhat different from what would be most satisfactory in bright clear cold weather, or rough stormy weather.

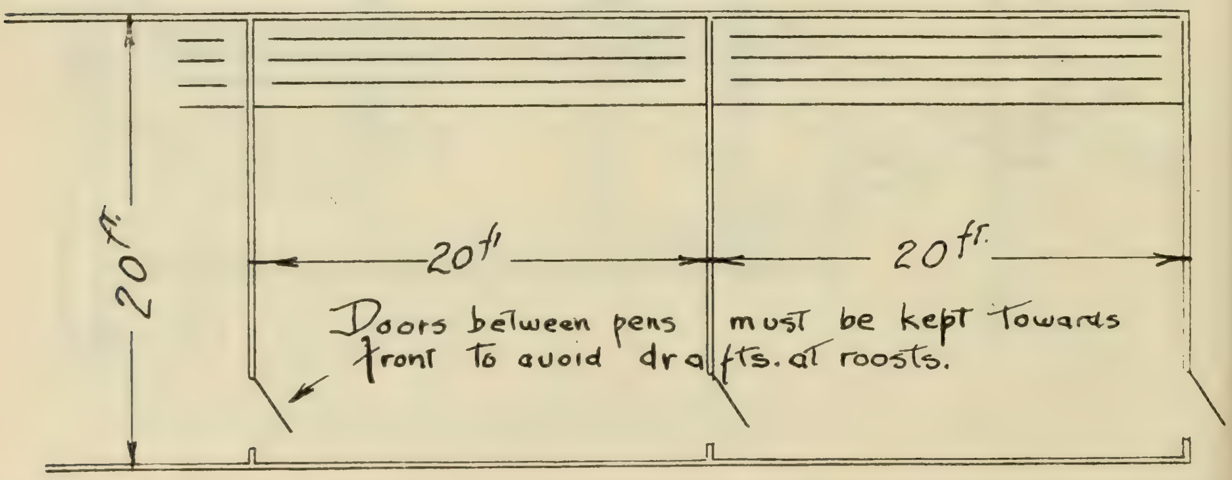
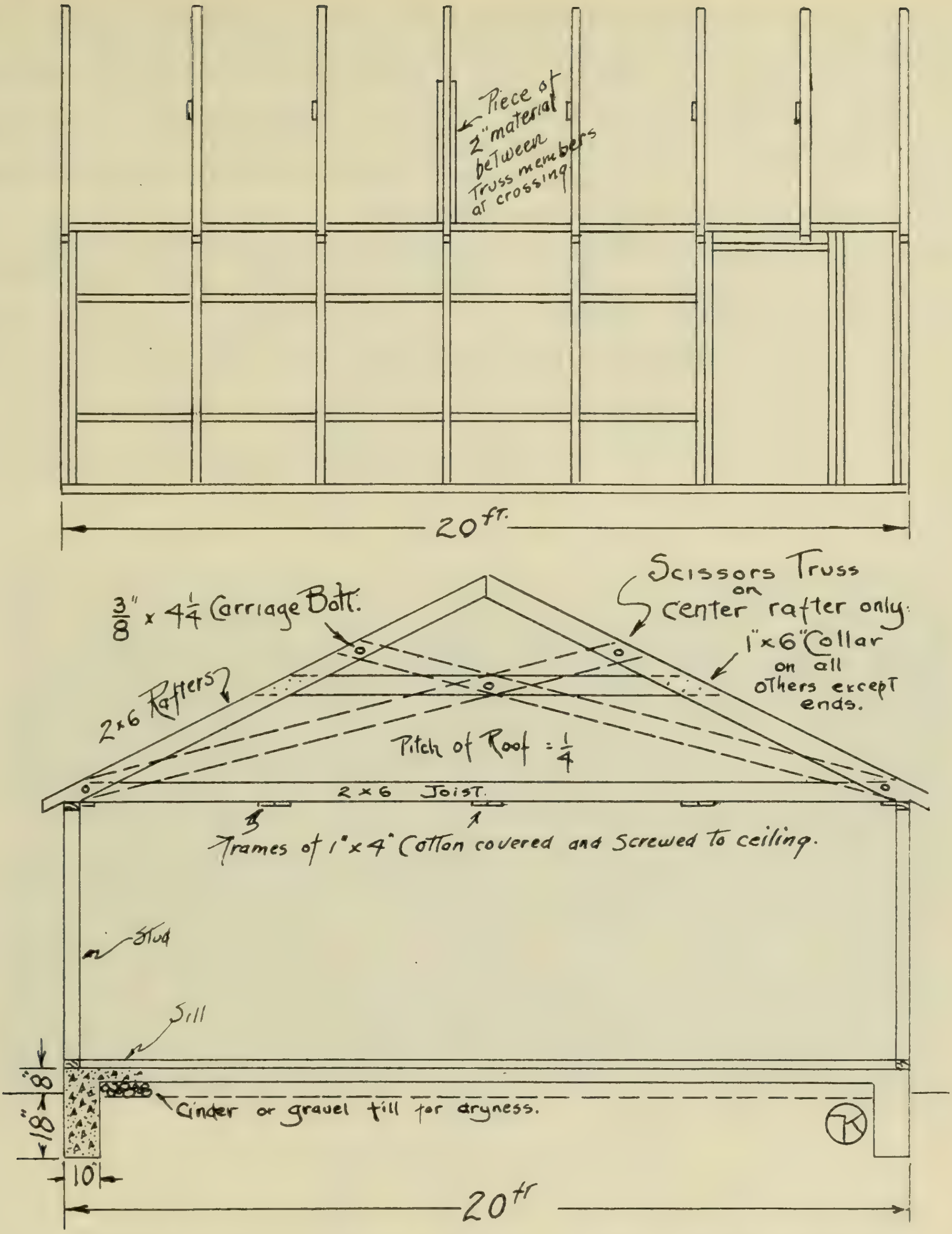

20 ft
20 ft
20 ft.
Doors between pens must be kept towards
front to avoid drafts. at roosts.

Fig. 35. Showing floor plan arrangement for pens twenty feet square. And the location of partition doors. This idea may be adopted either in Figures 34 or 36.


Piece of 2" material between Truss members at crossing
20 ft.
3/8" x 4 1/4 Carriage Bolt.
Scissors Truss on center rafter only.
1"x6" Collar on all others except ends.
2x6 Rafters
Pitch of Roof = 1/4
2 x 6 Joist
Frames of 1"x4" Cotton covered and Screwed to ceiling.
Stud
Sill
8"
18"
Cinder or gravel fill for dryness.
10"
20 ft

Detailed dimensions for this house may be taken from the 12 ft x 12 ft one.

Fig. 36. Plan showing framing construction for a house twenty feet in depth and twenty-foot pen, using the same type of construction for the front as in Fig. 34a. House is built with gable roof and for either straw or cotton loft.

OPEN FRONT HOUSE.

The question naturally arises: Can a house be constructed which is nearly self-operating, that will keep the birds in health, and at the same time ensure a fair egg yield?

Our experience has been that the fowls thrive best in low-down houses, especially during the winter. We have two houses with the fronts entirely removed except a two-foot wire netting, which keeps the fowls in, and the sparrows, etc., out. These houses, for this climate, must be low down, especially in front, to keep out the snow and the wind. It is the writers' opinion that Fig. 37 will meet the needs of the average farmer where he wishes to keep from seventy-five to one hundred hens. The house looks too cold, but the birds do well. They possibly could be made to lay more eggs during the months of January and February with cotton screens properly adjusted to meet the weather conditions; but few farmers would be there at the exact time to do the adjusting, hence we use it entirely open, or one half closed.

The large window in the west, essential for light, should be hinged at the top so that it may be opened during the summer months, otherwise the house will become too warm in summer.

BILL OF MATERIAL FOR OPEN FRONT 20′ x 20′ HOUSE

	Number of Pieces	Size	Length	
Sill	4	4″x 4″	20′	
Plates	2	4″x 4″	20′	
Posts:				
Back	4	4″x 4″	3′ 10″	
Front	4	4″x 4″	2′ 8″	
Cut and erect the above.				
Ends:				
Rafters	4	2″x 6″	12′	
Studs	2	2″x 4″	16′	
Studs	2	2″x 4″	12′	
Girts	2	2″x 4″	12′	
Ridge Board	1	2″x 6″	20′	
Cut and erect the above.				
Siding				400 board feet of 1″x 10″ S. 4 S
Battens				250 lineal feet of 1″x 2″ S. 4 S.
Put on siding but leave battens until roofing is on.				
Rafters	18	2″x 6″	12′	
Roof Sheathing				560 board feet of 1″x 8″ S. 4 S. Or better 625 board feet of 1″x 6″ Shiplay
Roll Roofing				5 rolls, 3-ply best. Do not put on until after trim.
Trim:				
Ends	4	1″x 6″	12′	
	4	1″x 3½″	12′	
	4	1″x 2″	12′	
Front	1	1″x 10″	14′	
	1	1″x 10″	8′	
	1	1″x 6″	12′	
	1	1″x 6″	8′	
	2	1″x 6″	12′	
	2	1″x 6″	10′	
Back	1	1″x 6″	12′	
	1	1″x 6″	8′	
	2	1″x 6″	12′	
	2	1″x 6″	10′	
Chicken Netting	¾″ mesh for front, 3′x 20′ piece.			
Door	25 board feet of 3½″ Pine V Joint.			

It will be noticed that no dropping-boards are used in this building. During the winter the droppings freezes almost as soon as it is made, hence no odour or bad results, and if cleaned, say every two months, it will answer very well. We would rather have this condition than dropping-boards covered one foot deep with droppings, as we frequently see them.

A number of houses of this style are in operation in various parts of the province, and they are giving fair results. In some of the colder sections, such as in the district north of Barrie, the house appears to be too open for severe winter weather. In such cases we would suggest using movable cotton screens on two sections of the front. The illustration shows three sections, one of which should always be open. During the winter months the centre screen may be closed nearly all the time and the end screen moved to either side, depending on the direction from which the wind is blowing. We have seen similar houses, two-thirds of the front of which were covered with a cotton frame, which could be thrown on the roof during bright, warm days and let down over the front during the cold nights and stormy days.

In a few cases, open-front houses have been built only twelve or fifteen feet deep and twenty or more feet across the front. This is not advisable, owing to the fact that should there be a direct wind blowing into the house the birds cannot get back far enough to be out of the draught. This is built to accommodate not less than one hundred birds, and will work well with as many as one hundred and twenty-five during the winter weather. If a smaller house than the twenty by twenty is desired it should be built, say, twenty feet deep and ten feet wide rather than ten feet deep and twenty wide. The width across the front should never exceed the depth.

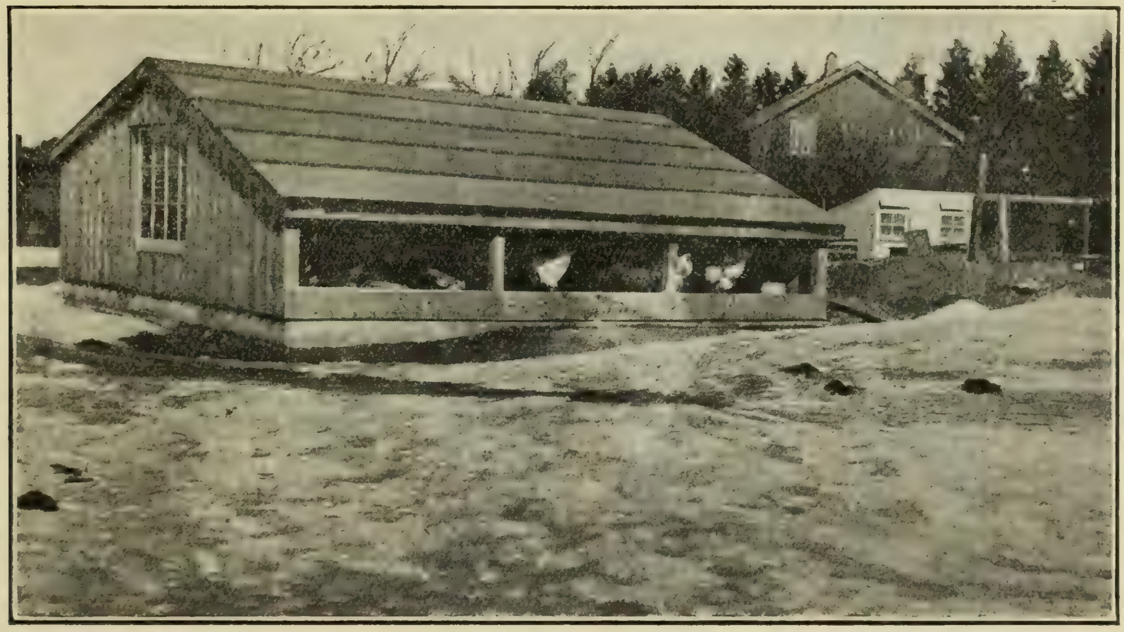


Fig. 37. Open front poultry house.

Snow will occasionally blow into the house, but we have had very little trouble in this respect. Having the building deep, low and narrow tends to prevent this. A rather small opening in front will not allow the wind and snow to blow far back into the house, and the depth allows the birds to keep out of the wind. If there is continuous rainy or damp weather for several days the litter will become damp and must be removed at once. Both walls and floors must be kept dry or the birds are likely to suffer from disease of some kind. There should be no opening except that in the front, or there is likely to be a draught through the house, and this should be avoided.

The following is the egg production for one hundred White Leghorn pullets and one hundred Barred Rock pullets from November 1st, 1921 to June 30th, 1922. These pullets were in two flocks housed separately in two open-front houses. (See Fig. 37.)

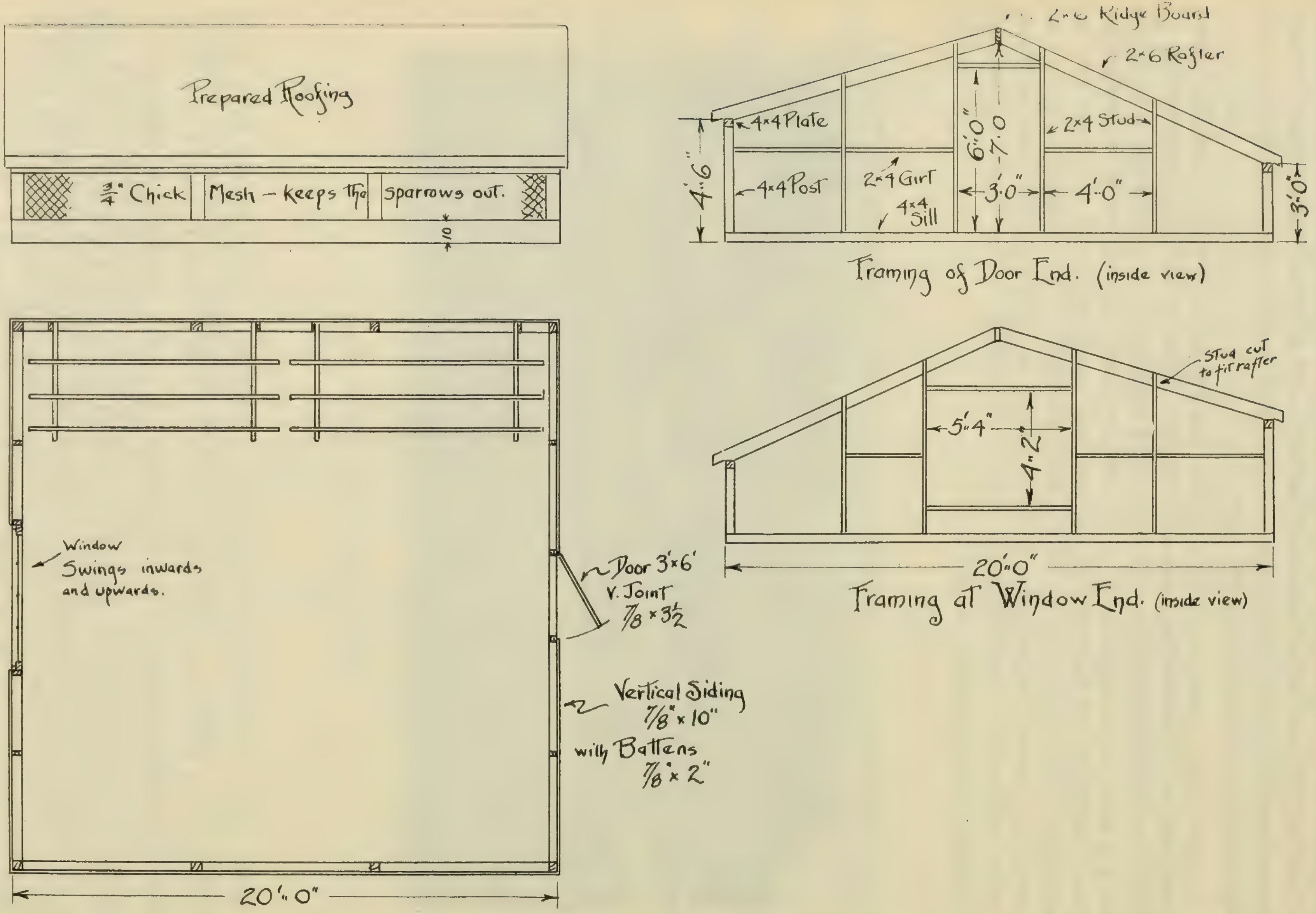

Prepared Roofing
3/4" Chick Mesh – keeps the sparrows out.
10
2×6 Ridge Board
2×6 Rafter
4×4 Plate
2×4 Stud
4'6"
4×4 Post
2×4 Girt
4×4 Sill
6'0"
7'0
3'0"
4'0"
3'0"
Framing of Door End. (inside view)
Stud cut to fit rafter
5'4"
4'2
20'0"
Framing at Window End. (inside view)
Window Swings inwards and upwards.
Door 3'×6' V. Joint 7/8 × 3 1/2
Vertical Siding 7/8" × 10" with Battens 7/8" × 2"
20'0"

Fig. 38. Plan elevation and framing sections of a 20-foot square open front house, suitable for the accommodation of one hundred hens.

	100 WHITE LEGHORN PULLETS	100 BARRED ROCK PULLETS
November	715	1135
December	590	1188
January	541	1091
February	1609	1335
March	2030	1753
April	2616	2339
May	1954	1632
June	1811	1487

While it would appear from the above production figures for Leghorns as though their production had been seriously affected by the weather conditions in December and January, this was not the cause of the drop in production. The pullets in both groups were hatched in February and began laying the end of July. The Leghorns moulted in November and December, and did not get back into full lay until February. Their production for October, preceding the period given above, was 1,336 eggs. The winter of 1921-22, while not extreme, was at times quite cold and the results as given above indicate fair production.

GENERAL RULES FOR BUILDING.

It is necessary to allow from four to six square feet of floor space per bird; the amount actually required depending upon the size of pen and the type of construction. The larger and more open the pen, the less floor space required per bird. Roosting requirements differ with the different breeds. Brahmas, Cochins, and such other heavy breeds, require ten inches of perch room per bird; Plymouth Rocks, Wyandottes, Rhode Island Reds, etc., require about nine inches; and Leghorns, etc., about eight inches. All perches should be placed on the level, as in Fig. 34. Perches where built ladder style will cause birds to crowd for the top perch, thereby causing trouble. Roosts should be made low or near the floor. There are several reasons for this. Birds of the heavy breeds cannot fly high up, and any bird is liable to injure the soles of its feet in jumping down from high perches.

When dropping-boards are used they should be moderately low down to admit of easy cleaning. Dropping-boards should be made of matched lumber and should be twenty inches wide for one roost and three feet wide for two, the first perch being placed ten inches from the wall and the others at fourteen inch centres.

Roosts two inches by two inches or two inches by three inches are preferred, the upper edges to be slightly rounded.

Cement floors are most sanitary, and are easily kept clean. The first cost is possibly high, but their durability commends them to general use. Earth floors are more in favour than wood and cost less. The greatest objection to the earth floor is the excessive amount of dust in the pen therefrom.

Cement floors for best results should be raised so that the surface of the floor is at least eight inches above the level of the ground. The intervening space is filled with cobble stones or coal cinders. A three-inch cement floor will be found heavy enough for the hen house; two and one-quarter inches of filling and three-quarters of an inch of finish.

Nests. These should be provided at the rate of one nest to every four or five hens in the pen. All types and sizes of nests are used, but with open nests placed on the floor trouble may be experienced with the hens eating their eggs.

This is overcome by providing nests which are partially darkened, as in the case of Fig. 39. Raising nests off the floor permits the use of the entire floor space for scratching purposes. All nests should be from twelve to fourteen inches square and not over six inches deep.

Trap-nests. This is a necessary evil where pedigree breeding is to be conducted. Whether it would be advisable for a man to trap-nest his stock will depend upon his object, and the time and expense he is willing to incur in attaining the same. The price of trap-nests varies from eighty cents to one dollar and eighty cents each. The cost of operating the same would be approximately one dollar per bird per year, which would not include all record keeping. Where trap-nests are used they must be visited at one and one-half to two hour intervals during the day. This is especially important during the hot summer weather, as otherwise birds are liable to die on nests from suffocation.

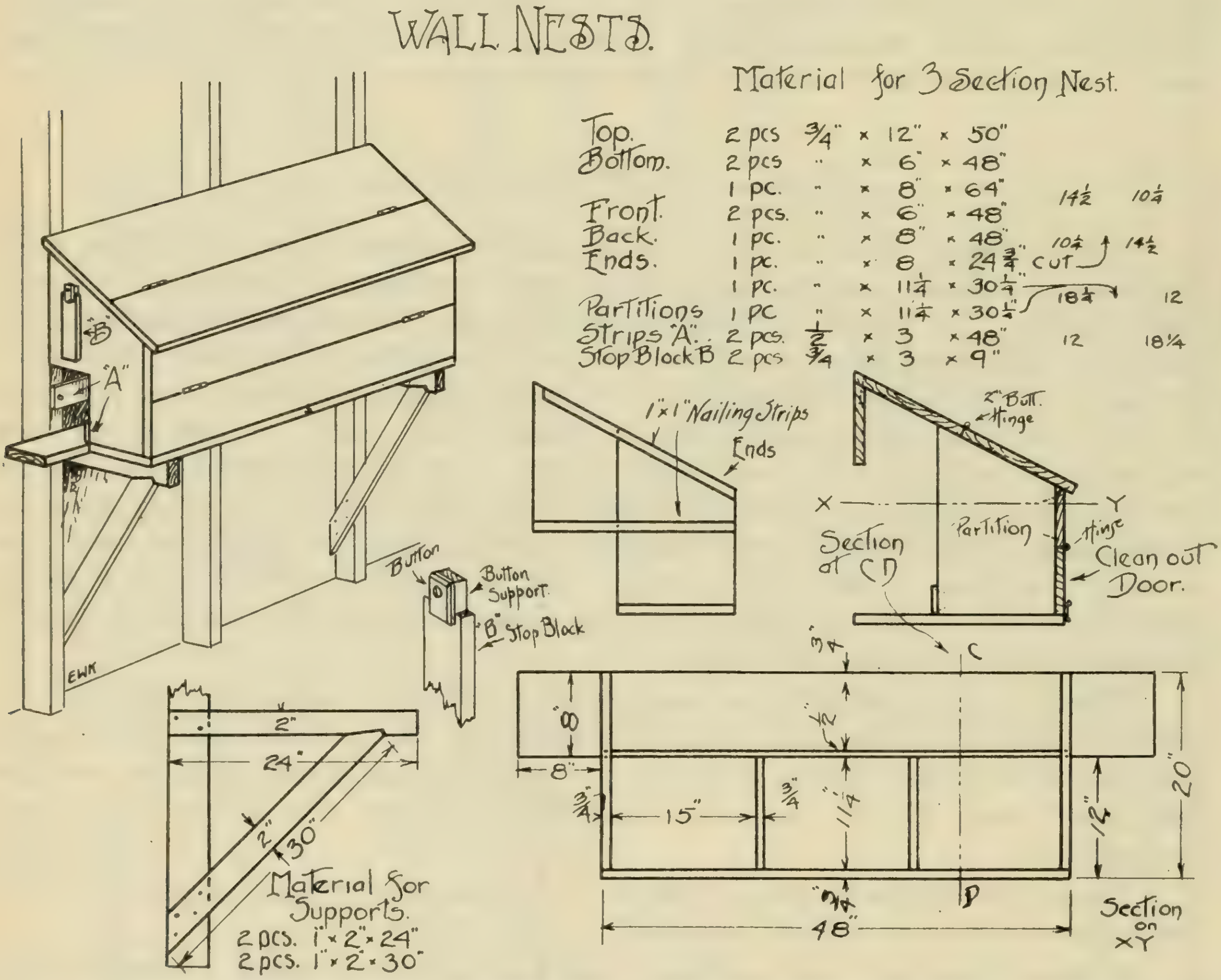


Fig. 39. A convenient type of open nest which may be supported upon brackets upon the wall allowing free use of floor space by the hens.

Trap-nests are for the most part patented. The nest which we have used for a number of years, and which we believe is as efficient as any on the market, is the one shown in Fig. 40. This nest represents in a general way the type of most trap-nests. It is made up of two compartments, with a trap or door on the front end which closes automatically with the bird's entrance into the nest, keeping the bird captive until released by the attendant.

The nest is constructed of seven-sixteenth inch material, twenty inches long, thirteen inches wide and thirteen and one-half inches high. The front of the nest is left open at the bottom which greatly facilitates the removal of the hen after laying. A three-inch board is placed across the bottom of the nest, inside, which divides the bottom of the nest into two compartments. The trap has a straight wire front and is so adjusted in the nest, that as the bird steps over the three-inch partition, her back coming in contact with the trap, tips it forward closing the next.

Drinking utensils of some form or other are necessary, and the more simple in construction, the better. The writers have found open pans as efficient as any, the size depending on the size of the flock to be accommodated. They should be made of some material which is smooth and as free from seams as possible, to facilitate cleaning, as frequent cleaning of drinking utensils is necessary to prevent them from becoming slimy and unsanitary. In large flocks we have used steel hog troughs, holding from twenty to thirty quarts, with good results.

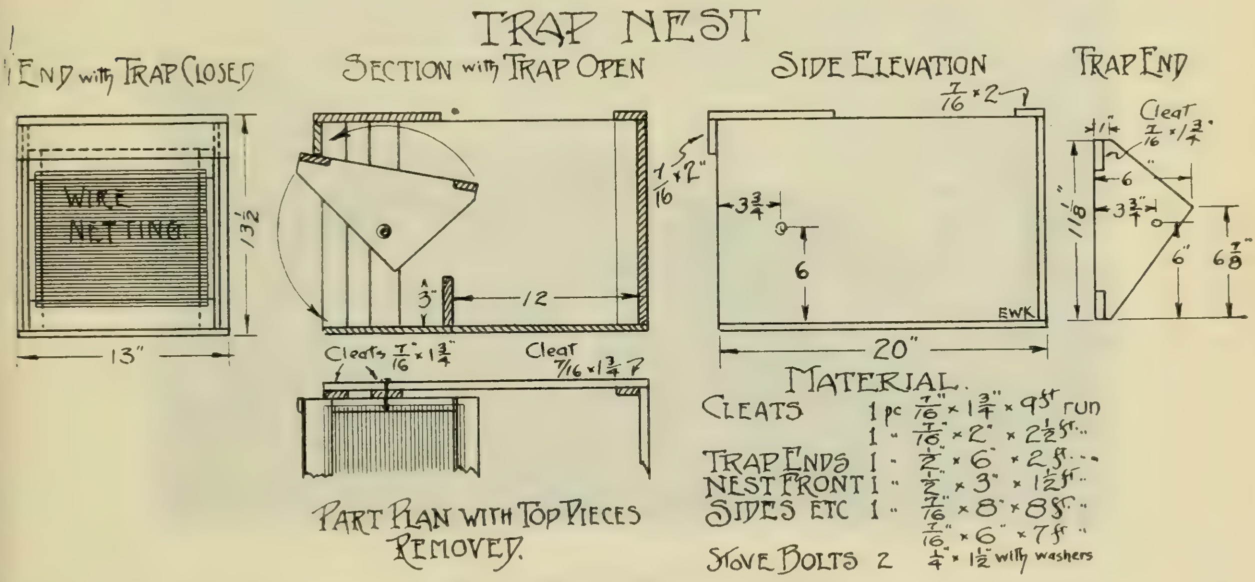


Fig. 40. Plan and specifications for trap-nest in which the type of construction of trap and its adjustment allows for the entire lower section of the front to be open. This greatly facilitates removing the hens from the nest.

In our experience the largest egg yields are obtained from flocks containing twenty to thirty birds. Some succeed with one hundred or more in a flock. Considering, however, the cost of housing, labour, etc., the most economical returns will be secured from flocks of about one hundred birds.

Colony Houses.

There is a constant demand from people living in towns and cities for plans of house suitable for housing six to twelve hens. In some instances they wish these houses so constructed that they can be moved easily from place to place.

The man who is using artificial means of brooding and raises over one hundred chicks, is finding the portable colony house a valuable adjunct to his equipment, as it enables him to place his young chicks on fresh ground every year.

The plans herewith submitted are adaptable to these conditions, and have been used by the writers for the purposes mentioned above. The house is of sufficient size to accommodate one hundred chicks to a two-pound weight, or fifty chickens to four or five pounds; but for winter use we would not advise putting in more than a dozen laying hens.

Bill of Material for 6 ft. by 8 ft. Colony House

2 pieces 4 in. x 4 in. x 10 ft., runners.
3 pieces 2 in. x 4 in. x 7 ft. 10 in., plates and centre runner.
2 pieces 2 in. x 4 in. x 5 ft. 10 in., end sills.
2 pieces 2 in. x 2 in. x 5 ft. 10 in., end sills.
50 ft. 1 inch matched flooring.
50 ft. 1 inch roof boards.
100 ft. run, ½ in. x 2 in., battens for ends and sides.
140 ft. 1 in. x 10 in., outside boarding; door, etc.
½ square shingles.
1 sash 6 x 10 x 12 glass.
1 cotton screen, fits on door.
1 door, 2 ft. 6 in. x 5 ft. 6 in.
1 cotton screen, fits on window.

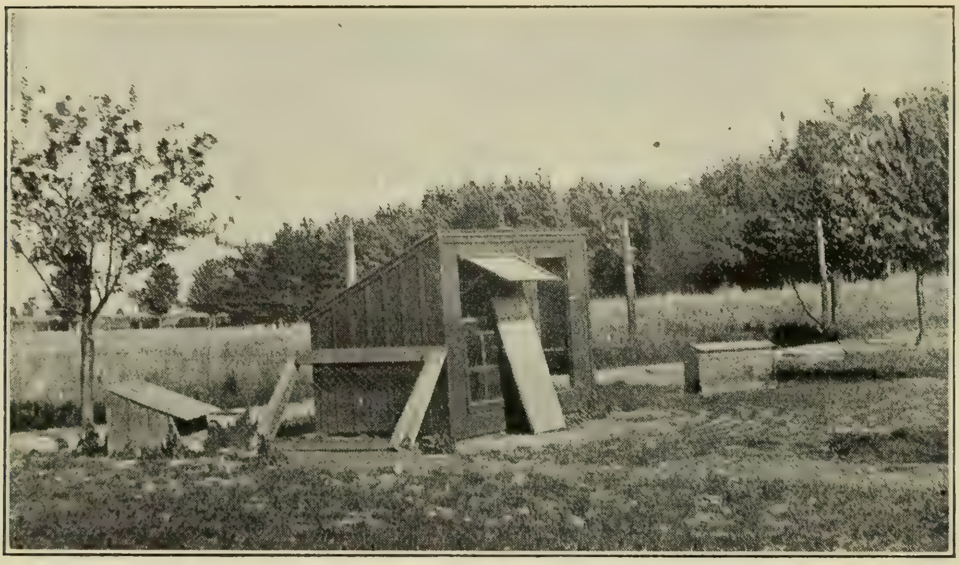


Fig. 41. Colony house 6′ x 8′

In Fig. 43 is shown a medium-sized portable colony house which is well adapted to the use of the large-sized colony brooder stove. It is built eight by twelve feet and while somewhat more difficult to move than the six by eight-foot pen, is more satisfactory and more convenient than the large house. It will accommodate 250 chicks until ten weeks of age and even older where they have an outside range.

BILL OF MATERIAL FOR 8′x 12′ COLONY HOUSE

3	pieces 4″x 4″x 14′—Hemlock, cedar or pine	Runners.
2	“ 2″x 4″x 12′—Hemlock or spruce	Runners.
2	“ 2″x 4″x 14′—Hemlock or spruce	End sills—Girts.
7	“ 2″x 4″x 16′—Hemlock or spruce	Rafters.
3	“ 2″x 4″x 12′—Hemlock or spruce	Plates, back girt.
6	“ 2″x 3″x 14′—Hemlock or spruce	Corners, door and window sides
3	“ 2″x 3″x 12′—Spruce	Roosts.
100	board feet, face 7/8″—Spruce flooring (16′ long)	Floor.
210	board feet, 1″x 10″—Outside sheeting.	
250	lineal feet, ½′x 2″—Battons.	
110	board feet, roof boards—Hemlock.	
1	square shingles.	
3	pieces 1″x 4″x 14′—Door and cornice.	
2	“ 1″x 3″x 10′—For cornice ends.	
1	sash, 1 3/8″ thick, 6 lights, 10″x 14″ glass.	

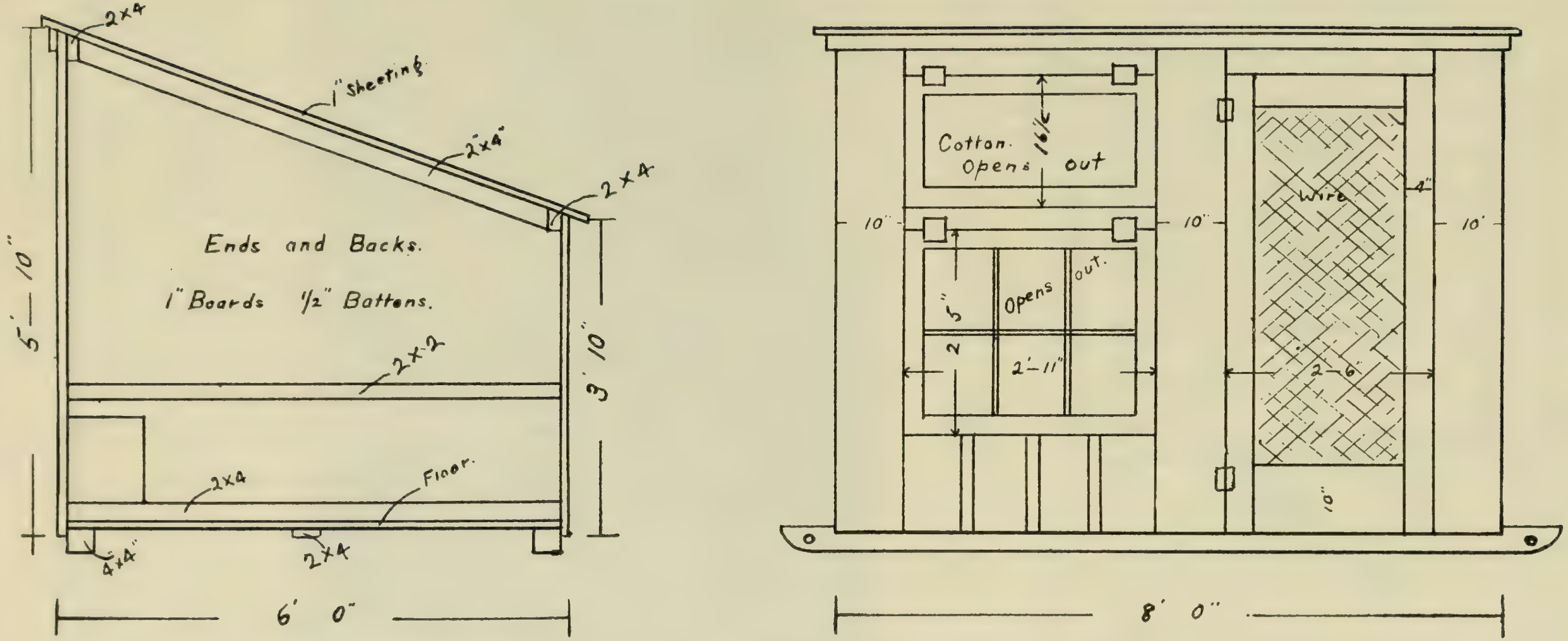


Fig. 42. Front elevation and cross section of 6 ft. x 8 ft. Colony house, Fig. 41.

COLONY HOUSE or BROODER HOUSE.

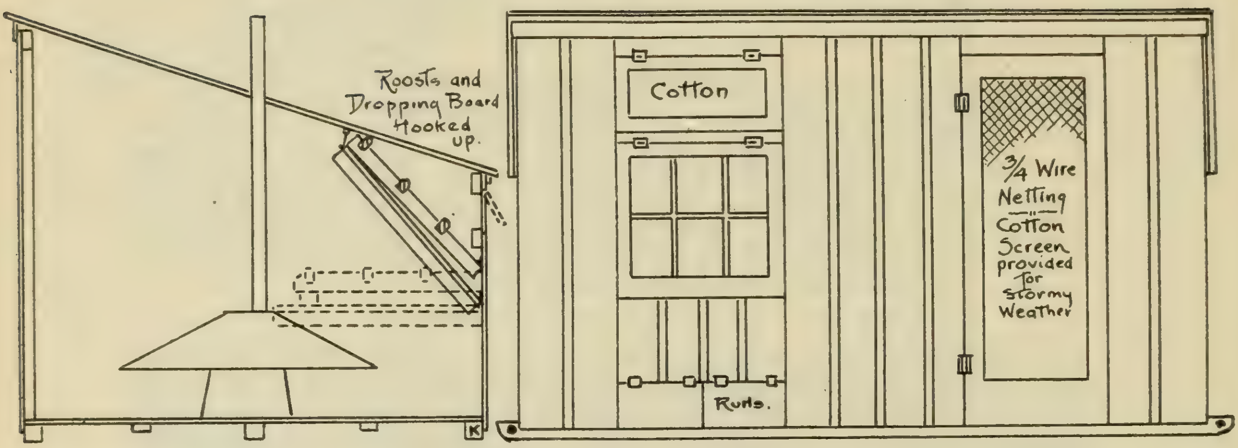
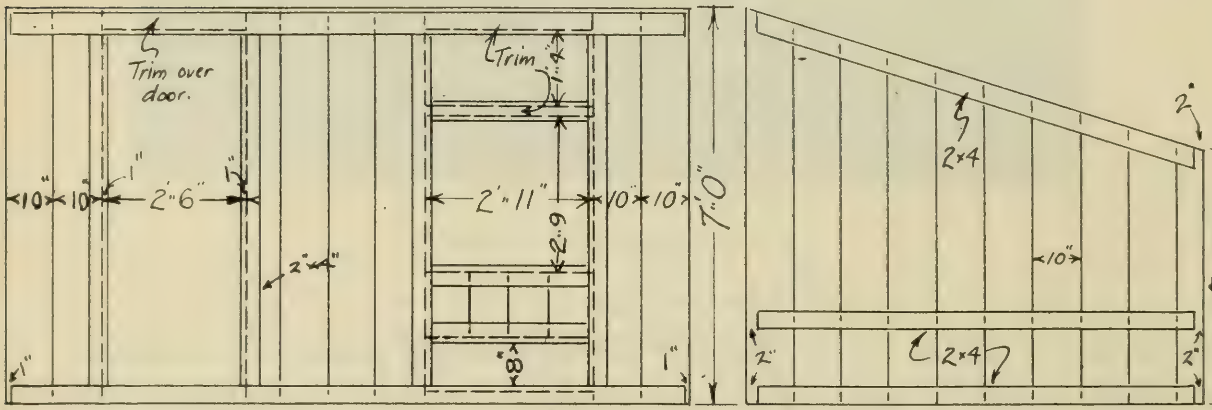
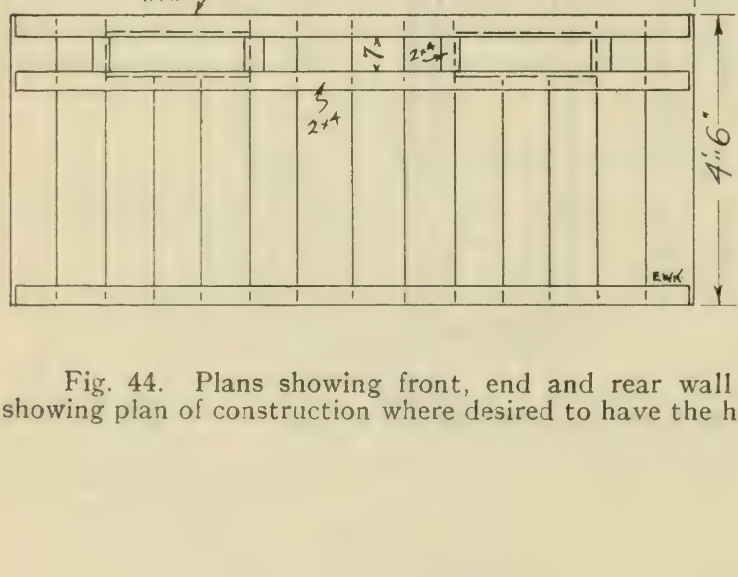


Fig. 43. Elevation and cross section of a colony house 8′x 12′ suitable for coal burning brooder stove.





These drawings show construction of Ends, Front and Back as they would be made if you wished the Colony House so constructed that you could take it apart for moving. The 2×4s are set in an inch to make a rebate for doors etc. The dotted lines represent the trim etc. as seen from the front. Roof & floor not shown.

Fig. 44. Plans showing front, end and rear wall construction of 8′x 12′ colony house, showing plan of construction where desired to have the house of the take down type

In Figs. 45 and 46 is shown a large type of colony house which is suitable for operating a colony coal-burning brooder stove, rearing chickens on range, or for a small breeding pen. The house is twelve feet by twelve feet, built on runners, and while portable cannot be moved as easily or satisfactorily as the smaller house. This house has been tested out by the writers both for brooding and for wintering laying hens and has proven quite satisfactory.

BILL OF MATERIAL.

3 pieces, 4 in. x 4 in. x 14 ft., runners.
11 pieces, 2 in. x 4 in. x 12 ft., hemlock joist plates.
16 pieces, 2 in. x 4 in. x 14 ft., hemlock rafters, studs, etc.
3 pieces, 2 in. x 2 in. x 12 ft., roosts.
220 ft. matched hemlock, roof boards.
230 ft. 1 in. spruce flooring 12 ft. long, floor and drop board.
300 ft. 1 in. novelty siding 12 ft. long, outside walls.
8 pieces, 1 in. x 3 in. x 14 ft. for window casings and cornice.
10 pieces, 1 in. x 2 in. x 14 ft. for screens (cotton for winter).
3 yds. 30 in. wire for screens (wire for summer).
4 yds. 36 in. wire for windows.
100 ft. ½ in. matched spruce sheeting inside, above drop board.
2 sash, 12 lts. 10 in. x 14 in., 1 3/8 thick.
2 square paroid roofing.
1 door, 2 ft. 7 in. x 5 ft. 11 in. and join.
Dropping board is 3 ft. 8 in. wide x 12 ft. long.
3 roosts 10 in. above drop board, 8 ft. long; about 12 in. apart.

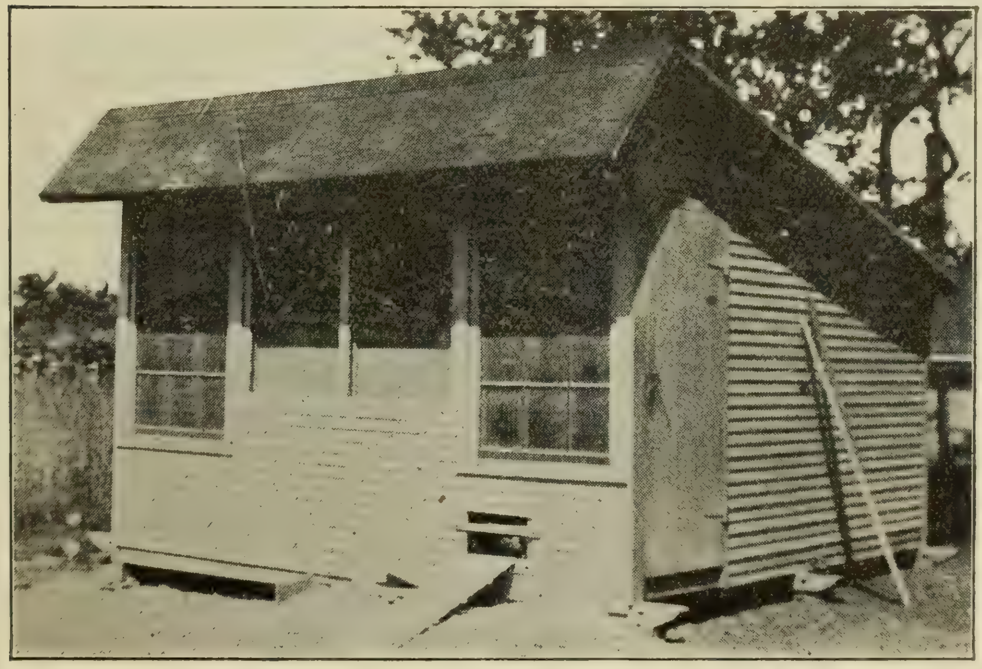


Fig. 45. 12 ft. x 12 ft. Colony house.

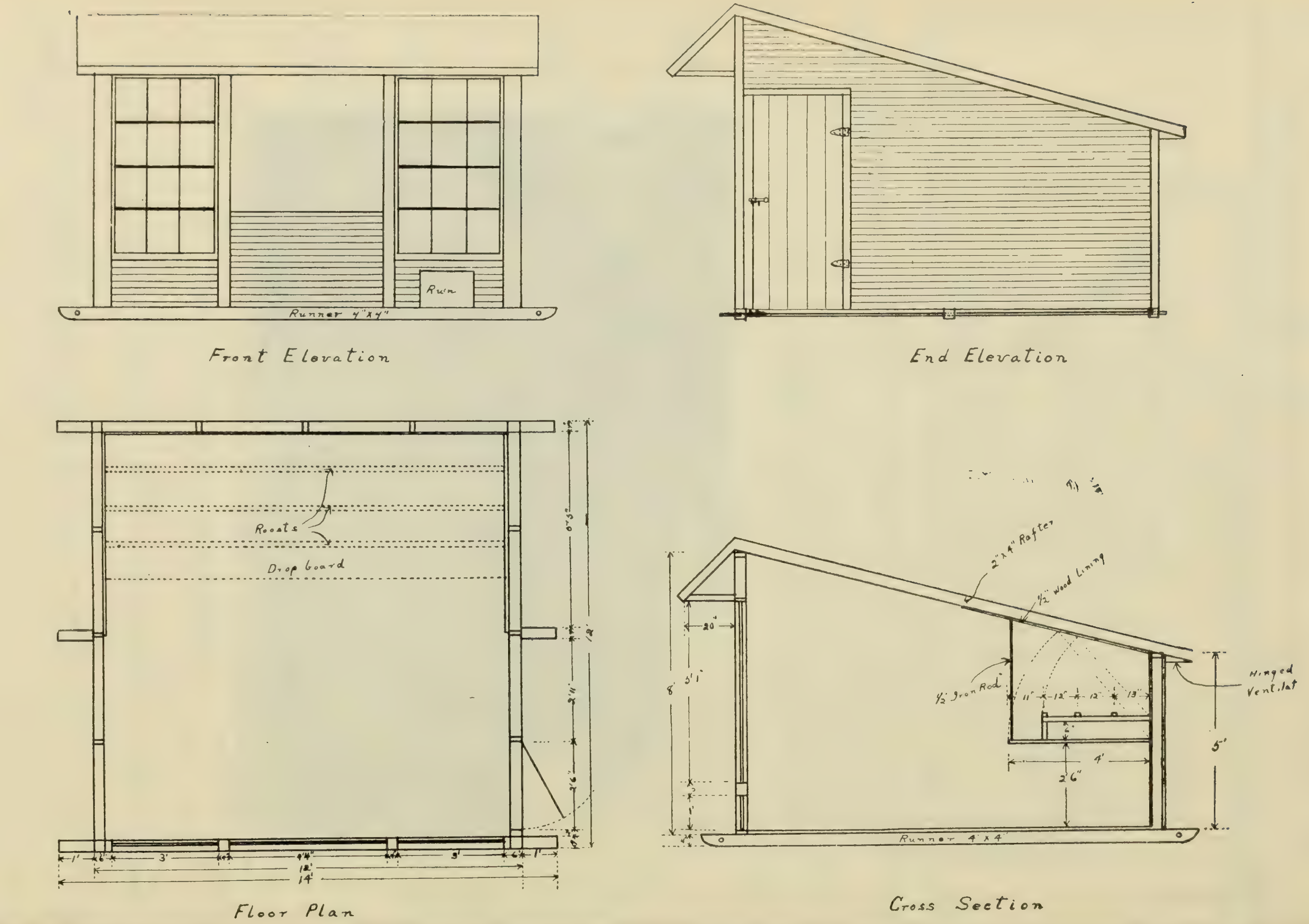


Fig. 46. Plans, elevations and cross sections of 12 ft. x 12 ft. Colony house, suitable for Colony brooder or laying pens.

FEEDS AND FEEDING

Fowl require a variety of feeds. While it is true that the whole grains and the milling by-products from the same form the major portion of the ration, it is absolutely essential that they receive also green feed, animal feed, drink, grit, and shell-forming material. All these feeds must be clean and wholesome, and furthermore, a portion of them should be given in some form so as to induce the birds to take healthful exercise. The drinking material should be given at regular and frequent intervals, and may consist of water or milk. The supply must be clean, as dirty water, dirty or slimy drinking dishes, etc., will do more towards making a flock unhealthy and diseased than possibly anything else. Most attendants are inclined to forget the drinking vessels and to keep them well filled at all times.

Recent investigations in regard to nutrition has helped to clear up some points on feeds and feeding.

In a ration it is well to bear in mind what feeds are required to maintain the body, to promote growth, to fatten the bird, or permit egg production.

It is essential that the health of the bird be maintained and that there be a surplus of digested feed over that needed for body maintenance, for the production of eggs, or growth, etc.

In general, it will be safe to state that grains, such as wheat, oats, barley and corn, together with their mill by-products, maintain the body temperature, produce fat and egg yolks.

Such feeds as skim-milk, dried milk or any of the many forms of milk, together with animal by-products, such as meat meal, beef scrap, raw liver, etc., go to the production of the muscle of the bird, and to the making of the white of the egg.

Feeds such as bone meal, oyster shell, lime stone gravel, etc., are used to produce the bones of the body and the shell of the eggs.

The whole series is required to make eggs. Many of the materials are found in small amounts other than those cited above. As an example, there is considerable lime in milk and in clover leaves, and wheat bran also contains some bone-forming material.

An understanding of feeding of poultry is helped materially by remembering that the bird can re-combine many things, but can manufacture but very little, if anything, not in the ration.

GRAINS

The average high production hen eats about ninety pounds of grain each year; or say a bushel and one-half of wheat.

The grains are used for the most part in maintaining the body heat, the production of fat and the building of yolks.

They all contain some proteins, the availability of which is in doubt; but a portion of these proteins is used.

One may look forward toward additional information in the future as to the best method of using these proteins.

Grains are fed both whole and ground; also the many by-products, such as bran, shorts, oat flour, etc.

Some are now advocating feeding only ground grains. Our limited experience with ground grains only for laying hens, would not warrant complete endorsation of this method of feeding.

Most poultrymen feed, during the fall and winter, roughly, six pounds of whole grain to four pounds of mash, and during the summer nearly the same amounts of each.

The value of the different grains for feeding poultry varies both with the chemical composition and the physical properties of the same. For instance, we find some grains which, considered from their chemical composition, are excellent feeds, but due to the high percentage of fibres, etc., are not satisfactory for feeding in the whole state. Fibrous material is only very slightly digestible by fowl, owing to the structure and actions of the organs of digestion, hence their low feeding value.

Wheat is, without doubt, the most popular whole grain in use by poultry people of Ontario, and is one of the best. It is relished by all classes of poultry. The price of wheat as compared with that of other grains during the past few years, makes it necessary to mix other grains with it. It is very doubtful whether it is advisable at any time to feed only one kind of grain constantly, and a variety is better; some birds like one grain while others relish another. Plump, soft wheat is usually more palatable for the birds than hard wheats, but the latter may have slightly higher feeding value.

Wheat bran is used largely as an ingredient of a mash. It is not credited at present with having as high feeding value as it was once generally thought to have. Its greatest value is in giving bulk to the ration, preventing impaction of crop and stomach, and aiding the digestive juices in their action on the feed. Wheat bran is also more or less laxative.

Wheat middlings is used extensively in poultry rations, particularly in baby chick rations.

Wheat shorts, in most instances, is not as free from ground weed seeds, etc., as is wheat middlings. Shorts is used more in rations for laying hens than in chick rations.

Both of these feeds are useful in checking looseness of the bowels where an excess of vegetables has been given.

Low-grade flour is often a cheap and economical feed to use in mashes for stock birds or for fattening chickens. It is more or less constipating, resembling middlings and shorts in its action.

Corn is not used as extensively in Ontario as it is in the Central and Eastern States. In those parts it forms the major portion of the whole grain ration. Corn is more of a heating feed, and while very satisfactory for feeding even in large quantities during cold weather, is likely to cause excessive broodiness, especially in the heavy breeds, if fed heavily during the warm weather. It is used whole, ground, or cracked, the meal being used principally in mash feeds. Whole corn is too large and conspicuous, and when scattered in the litter does not usually give sufficient exercise. In the opinion of the writers, corn can be used in those section of Ontario where it is grown extensively, much more freely than it has been in the past.

Oats would be much more valuable for poultry feeding, if there was not such a large percentage of the grain hull or fibre. Fibrous material, such as oat hulls, is practically indigestible by poultry, and besides, in some birds, has a tendency to clog the digestive tract. When rolled, with hull on, they make a very satisfactory form of dry mash and in this condition are greatly relished by the birds. Oats are, without doubt, the best grain to use for sprouting for green feed supply.

Oat flour and oat middlings are by-products from the oatmeal mills. They contain a very small percentage of fibre and are used extensively for fattening purposes.

Barley is most valuable for feeding, when finely ground or rolled and used as an ingredient in a fattening ration. It contains rather too much hull for feeding in the whole state, and unless very well threshed, so as to remove entire beard, it is not advisable to use without grinding.

Buckwheat is very popular as a whole grain in sections where it is extensively grown. It is sometimes difficult to get fowls to eat it at the first feeding. This is easily overcome in a few days if its feeding is continued and other feeds withheld. After they once become accustomed to its appearance it is much relished by them. It somewhat resembles corn in its fattening properties and, therefore, it is better for winter than summer use.

Ground buckwheat, ground hull and all, is an excellent feed to use in a fattening ration.

Rye and peas are not suitable for feeding extensively as whole grains, but may often be used economically if ground and used as ingredients in a mash for fattening purposes. Large quantities should not be used of either as they are each strongly stimulating.

ANIMAL FEEDS OR PROTEIN

These feeds supply the white of eggs in particular, as well as a large part of the lean meat, or muscle of the body.

Protein from an animal source appears to be much more available to poultry than protein of a vegetable source; or, it might be stated, as yet the proper combination that will render the vegetable proteins more available is not known.

Animal feeds are the most expensive feeds given to fowls. These are used as a substitute for the worms and insects that form a portion of the natural summer feed of fowls upon free range. Flocks confined to small runs require to be fed more or less animal feeds during the summer; and during very long dry spells in the summer, even where the range is unlimited, it frequently pays to feed a little animal feed.

Animal feeds usually assist very materially in the production of eggs in winter. By some people these feeds are considered as a forcing feed; that is to say, they will induce heavy laying, which in some instances may be followed by serious sickness, or possibly the injury may be only very slight, in fact, unnoticeable, except that the eggs from birds so fed may be of very low hatching power.

It is generally believed, and we think rightly so, that good egg yields cannot annually be secured without the use of such feeds as green cut bone, beef scrap or cooked refuse meat, etc. Many believe that the larger the amount of these feeds fed the greater will be the egg production. There is good ground for doubting this statement, in that these feeds are expensive and the extra eggs may cost more than they are worth. Moreover, here is where serious injury may be done to the hen's digestive and reproductive organs.

The proteins of milk appear to be exceptionally well adapted to poultry, both for growing chicks and for the production of eggs for hatching.

Milk is now available for poultry use, not only as skim milk or buttermilk, but in the powder form, as well as semi-solid buttermilk.

One hundred hens require about twenty pounds of skim milk daily; or, where semi-solid buttermilk is used, from four to five pounds daily; and where the powder form is used about one and one-half pounds daily.

Many find it profitable and convenient to use one of the prepared meat feeds, such as beef scrap, meat meal and meat and bone meal. There is no question but what these feeds materially help egg production.

The amounts given vary somewhat. In the opinion of the writers, not more than 20 per cent. should be used in a laying mash, and in most cases 5 per cent. in growing rations.

It is not a bad practice to use, say, 5 to 7 per cent. of beef scrap in a laying mash and supplement this with one half the milk ordinarily given.

WATER

An egg is about 66 per cent. water and the body of a fowl is about 55 per cent. water. Water is used constantly in the digestion of feeds and in cleaning the system. Water is important. If it was not so easy to procure, perhaps it would be given more attention. Water may be a carrier of certain diseases. A bird needs a constant supply of good pure water. If the water is too cold, the bird may not drink enough, and if the water is from a barnyard, or a dirty drinking vessel, it may carry disease.

Clean water, and plenty of it, is an essential.

GREEN FEEDS

Green feeds supply certain vitamins, some essential minerals, and aid digestion.

The birds enjoy tender green feed. It is easy to get in the spring and early summer, but generally in the dry, hot months of July and August, as well as when the ground is frozen, it is often neglected.

Good tender grass is perhaps the best available. For July, August and the fall months, any kind of tender green leaves will do; such as, rape, spinach, beet leaves, green cut alfalfa, etc.

During the winter months, the problem is more serious. Most poultrymen are using high quality clover leaves or alfalfa meal. These are very good substitutes, except in succulence. Some are supplementing these feeds with a few roots, just enough to keep the bowels normal. Cabbage makes a good all-round green feed for fall and winter.

Germinated or sprouted grain, such as oats, is very good, and where one has the facilities for germinating oats, they give good results, especially where clover leaves or meal is fed in addition.

MINERALS

The question of minerals in a ration is daily being more closely studied.

Direct sunlight, not sunlight through glass, appears to have a very considerable influence on the birds' ability to use the mineral feeds. The writers feel justified in placing direct sunlight as the first essential to the feeding of minerals.

Cod liver oil in doses of about 2 per cent. of the mash feed, has given very good results as a partial substitute for direct sunlight.

Oyster shell is the common source of lime for the egg shell. On the ordinary farm, the shell material comes from limestone grit, of which there is considerable in the common gravel.

Bone meal supplies the phosphate and lime for the growing chick and the old bird.

Considerable mineral comes from alfalfa or clover leaves, green leaves in general and from milk.

Hens that lay thin-shelled eggs and lose the use of their legs, where there is an abundance of osyter shell, etc., will usually make a quick recovery by feeding 2 per cent. of cod liver oil added to the mash and permitting the birds to get in the direct sunlight, when the sun shines.

These mineral feeds, together with the sunlight, appear to have much to do with the production of good hatching eggs.

Rations for Laying Hens

There are many combinations of grains that make very good rations. The price of feeds, the quality of the grain, and the ration that the birds have been accustomed to getting, are all considerations.

It is not a good plan to change quickly from one ration to another, but to change gradually over by mixing some of the new ration with some of the old, and increasing the amount of the new every day or so. As far as possible do not change the ration, if the one you are using is giving fair results. A sudden change in a ration during the winter months may produce a moult, or the flock may go down in egg production.

The ration used at the present time consists of a scratch grain made of 50 per cent. whole wheat and 50 per cent. cracked yellow corn. A little of this is fed in deep litter in the morning, and a full feed is given at night.

A dry mash is kept before the birds continually, which at present consists of the following:

700 pounds of yellow corn chop.
500 pounds of shorts.
300 pounds of ground oats.
150 pounds of alfalfa meal.
7 pounds of fine table salt.
50 pounds of bone meal.
3 gallons of cod liver oil.
25 pounds of milk to 100 hens daily.

Where one has plenty of clover leaves the alfalfa meal may be omitted, and a bushel of clover leaves fed daily to one hundred hens. During the seasons of the year when there is plenty of sunshine and green feed, the cod liver oil is not required.

Oyster shell and grit are available at all times. These are fed in boxes or hoppers.

The above ration is high in corn. When the flock is laying 50 per cent. or better, the birds are inclined to lose weight. Corn is very palatable, and one of the best grains to maintain body weight.

Many other rations have given good results. Rolled or crushed oats have been used as the mash and wheat as the only grain. Where the birds have plenty of milk and clover leaves this ration has given good results in egg production. Rolled or crushed barley has been used in the place of the oats with good results.

The above are cited to show that what grains you grow may be used.

Where milk is not available it is necessary to feed some animal feed, such as meat meal or meat scrap. The amount of this material to put in a laying mash is from 15 to 20 per cent. Meat scraps should be thoroughly mixed in the mashes. They do not mix well with rolled oats or barley alone, but do mix well with finely ground grains.

It is necessary to have plenty of good clean water or milk to drink.

During cold weather the drink should be warm, as the birds will not take enough ice cold drink. If the birds want to eat some snow it will not hurt them.

Feeding A Moist Mash

Many have good reasons for feeding a moist mash once a day, just what the birds will clean up in fifteen to twenty minutes. One may desire in cold weather to give at least one feed that is not freezing cold; or there may be cooked vegetables or even some cooked meat to be given. Others prefer to feed the cod liver oil and the semi-solid buttermilk in a moist mash.

Moist mashes take more labour, but many poultrymen believe they can get a better egg yield, especially during the winter, if a moist mash is given.

The Art of Feeding

There is something in the art of feeding. A good feeder watches the condition of the manure as seen on the dropping boards and also sees to it that the hens have plenty to eat but have no feed lying around in the litter on the floor. The appetites of the birds are keen, and moreover the birds like the attendant. There is a friendly feeling between the attendant and the birds. Know your birds and have them know you. Be on friendly terms with one another.

The Use of Lights for Increasing Winter Egg Production

A number of trials have been made with electric lights and gasoline lanterns towards increasing the egg yield during the short days of winter.

The results indicate that the maximum amount of light to be used, including the daylight, is thirteen hours; and in most instances twelve hours will give just as good results.

Extra hours of light will increase egg production temporarily, but this is generally followed by a low egg production and a moult.

The practice of turning on lights at six o'clock in the morning and turning off at the same hour at night, all things considered, is convenient and will give good results. This plan admits of making no change as the days lengthen.

Sudden changes of time, etc., are almost sure to result in low egg production.

Lighting must be regular to be of any benefit. Lights usually increase the winter egg production about 20 per cent. and the total yearly production but very little.

A METHOD OF FEEDING AND MANAGEMENT FOR PRODUCING GOOD HATCHING EGGS FROM HIGH EGG PRODUCING HENS

There has been a problem of getting a reasonable hatch from eggs laid by hens that, in their pullet year, produce 200 to 300 eggs. A number of trials in regard to feeding and management have been made with some success.

The plan as now practised is as follows:

Most pullets complete their first year's production about November 1. The selection of suitable birds for the next season's breeding is fairly complete sometime in October, and the birds that have been in laying competitions will be back to the plant the first week in November.

Birds to be considered as next season's breeders are put out on a good grass range, and where there is also a patch of rape. The colony houses that were used for raising chickens are moved to this range. The hens are transferred to the colony houses, about fifty hens to a house eight by twelve feet floor space.

This house simply gives them roosting space. All mash feed is removed; also all milk or animal protein. The birds are given a ration of whole grain, water and green feed, and allowed to range as they please. A few days will completely stop egg production. The birds moult; the yellow returns to their legs and beaks, and they have a real holiday. There are enough birds in a house to keep it moderately comfortable on rainy and cold days; a few hens will possibly be lost owing to lack of physical fitness.

Our method is to allow these hens to remain on range at least two months, after which they are placed in breeding pens.

One usually has some very old, high-class breeding hens that have demonstrated their worth as breeders. Usually the old hens are late to start laying, and moreover the first three or four eggs laid by a hen after a period of rest are seldom fertile. The selected old hens are kept because one wants chicks in numbers from them, particularly in March and April. It is our practice to use a little artificial light on these hens so that they may be laying a high percentage in February. They are fed a ration the same as the pullets, using milk as a protein source, and care is taken that they have plenty of clover and bone meal. As far as possible these birds get what direct sunshine there is, and get out of doors if the weather permits. They have two per cent. of cod liver oil, or cod liver meal, in their mash mixture.

The Department has used the above plan on upwards of a thousand breeders for the past four years, with satisfactory results.

Hatching power of eggs is an inherited factor that is influenced by environment. Some hens' eggs are low in hatching power; others are high in hatching power. The above methods of feeding and management has given good results, no matter how many eggs the hen may have laid in her pullet year (when her breeding is considered).

INCUBATION.

The renewal of the flock is one of the most uncertain problems with which the poultry keeper has to deal.

The number of eggs taken to produce a chick influences the cost materially. The factors that may influence the hatch are many, including the maturity, age, and breeding of the parent stock; the kinds of feed and the method of feeding; the method of incubation and the type of incubator, including the room used for ncubation; and the operator is as important as any factor.

With many factors influencing the result, the cause or causes of failure are difficult to locate and, further, many of these problems are not easy to investigate.

The operator must be painstaking, accurate and methodical in his habits. The management of a large number of sitting hens, or the operation of incubators, requires careful attention at regular intervals. Because an incubator is equipped with a regulator does not mean that the incubator will take care of all possible variations in temperature, nor will a heater produce the required units of heat without fuel. The operator must realize that he must do his part.

The room in which incubators are operated must be well ventilated without producing direct drafts over the machine. The air of the incubator room should be as pure as that in a living-room. The less variation in temperature within the rooms the easier the machine will operate. Any well ventilated, *clean* cellar or iving-room will answer.

Machines as a rule run better when set along a wall or corner of the room. They should not be set in direct line between an open door and a window. If so placed, unless screened, the lamp may go out and the machine heat unevenly.

Machines for hatching eggs are now sold varying in capacity from fifty eggs to forty thousand eggs. The large machines are gradually replacing the smaller machines. The reasons are clear, in that the larger machines are more economical with labour and fuel. The general tendency is towards central hatching stations where one may have eggs hatched at a given price per egg or where one may buy day old chicks. Many find incubating a good business and others prefer to go to a hatchery and get their year's supply of chicks and not worry over sitting hens or small lamp incubators.

Many makes of incubators have been used at this Department, and most of them will give very good results if carefully managed. We have seen no one incubator that excelled all others.

Operating an Incubator.

Given a suitable room, the first thing is to clean the machine before and after every hatch. Brush the machine clean, wash it out with hot water, then spray or wash it with a disinfectant. The next operation is to set the machine level. The thermometer must be accurate, and to assure accuracy it should be tested at least once, or better, twice during the year. The temperature given is usually one hundred and three degrees Fahrenheit throughout the hatch. Our experience has been that it is better to take an objective of one hundred and one or one hundred and two degrees, and if the machine creeps up to one hundred and three degrees we have no cause for worry; but given a temperature of one hundred and three degrees, when the machine goes up to one hundred and four or above, usually either the hatch is small or the chicks hatched are hard to rear. Low temperatures are not so fatal as are high temperatures.

The amount of moisture required in an incubator depends upon the make and the room. Generally it is best to follow the manufacturer's directions.

Hatching by the Natural Method.

Setting the Hen. It is generally agreed that, in order to secure a goo hatch, the hen must be placed where other hens are not likely to disturb her; for as a rule, we seldom get good hatches when other hens lay in the nest with th sitter. Some farmers do not set a hen until one becomes broody on a nes where no others lay, which often necessitates late chicks. The difficulty can b overcome by making a new nest for the broody hen. A box about twelve inche square and six inches deep; some earth, or an overturned sod in the bottom with care to have the corners very full so that no eggs can roll out from the he and get chilled; next, about two inches of straw or chaff, and then a few earthe eggs put into the nest. The nest should be placed in some pen where nothing ca disturb the hen, and put her on after dark. Feed and water must be withi easy reach, and a dust bath should also be convenient. If the hen is sittin quiet the next day, you will be safe in putting the eggs under her. In ou experience we get ninety per cent. of the hens to sit by following this method.

It should be remembered that the hen will be in better condition if duste with insect powder when set, and also a few days before the hatch comes of This will usually keep the lice in check, especially if some tansy or mint leave are used in making the nest.

SELECTION OF EGGS.

Select for colour, size and shape, the kind of eggs you want for market. Continuous selection, year after year, will give results. Do not select dirty eggs, nor do not handle eggs unless your hands are clean. The shell is porous, hence there is possible contamination.

Eggs deteriorate in hatching quality with age. When you hold eggs for hatching keep them in a cool place about fifty to sixty degrees Fahrenheit. Be sure the place is clean and not musty. Eggs for hatching should be kept not longer than ten days.

The increasing difficulty of obtaining nut coal has developed a large oil-burning stove. It is gradually being tried out and may in the future become fairly popular. It is reasonably safe, and there are no ashes.

Brooder houses, whether permanent or movable, should be constructed so as to be easily cleaned and the ventilation controlled. Many chicks are lost by bad air and eating filth. The brooder house should be comfortable, not hot and stuffy.

The chicks are comfortable when they circle the edge of the hover. They easily develop bad habits. Too much heat may cause them to bunch in corners and smother one another or too little heat may do the same. A lack of fresh air is at times a cause of drooping wings and worn appearance. The average operator soon learns to know when the house is comfortable and the chicks appear to be happy.

PREPARING A BROODER FOR CHICKS

Place your brooder as near the centre of the pen as possible, and our experience has been that the stove burns better if the pipes go straight up through the roof.

There is generally a considerable deposit in the stove pipes which makes it necessary to clean the pipes at least once every three weeks, and oftener during damp weather.

Do not place the colony house close to trees, buildings or other obstructions with air currents, otherwise one may have considerable trouble with lack of draught and slow burning coal.

Learn how to operate the coal stove before you put the chicks around it, and remember that high windy days and nights mean more attention to the stove, or it may burn out.

Baby chicks seldom have very much natural selective influence about feeds, and some will eat sand, shavings, or anything in the place of the regular feed.

For the first three or four days, we prefer to use papers on the floor and no other litter. After the chicks have learned to eat and drink, then we use cut alfalfa hay as litter. Do not use *mouldy* or *musty* litter of any kind.

Run a circle of wire netting, one inch mesh, around the hover, at least two feet from the edge of the hover. This keeps the chicks near the source of heat and prevents bunching or crowding.

If the sun shines in the pen near the brooder, white wash, or cover the windows, for at least the first week. Chicks like to huddle in the sunshine and odd broods learn to bunch or crowd in this way.

Enlarge the wire circle from time to time, as the chicks grow. They will very soon require the entire floor space. Watch the corners of the pen. It is generally good business to put some wire netting near the corners so that the chicks cannot get in bunches or pile.

Keep the room comfortable and the air pure. The odour of the pen will suggest the amount of ventilation.

Put in some small roosts as soon as the chicks desire to perch. They will sit on the perches considerably during the day, long before they roost at night; but all the time they are getting the roosting habit, and once on the perch at night, they require much less attention.

It is a good plan after the first week in the brooder to have a small box of grit and fine oyster shell for the chicks to eat, if they want it.

REARING CHICKS

Success with chicks necessitates a complete ration, and the use of a reasonable amount of common sense.

Chicks reared in a colony house, or by the artificial process, require to have every need of life and growth taken to them.

1. Vitamins are essentials to life and growth, and are commonly found in tender greens, yellow corn, eggs, cod liver oil, direct sunshine and well cured immature clover.
2. Animal proteins, such as are found in milk or animal meals.
3. Grains and their by-products, such as corn, wheat, barley, middlings, etc.
4. Minerals as supplied by bone meal, milk, oyster shell, ground lime stone, clover leaves, etc.
5. A movable, comfortable house, with adjustable ventilation.
6. A heater of sufficient capacity and reasonable control of the same.
7. Clean ground for range.

The Dry Mash Method of Feeding Baby Chicks

Where chicks are reared in large numbers or where there are many daily duties that require attention, the dry mash method of feeding is worthy of a trial.

The mash we have used is similar to that used by several experiment stations. It consists of the following mixture:

70	pounds of yellow cornmeal (of a grade equal to or better than No. 2 Yellow).
30	pounds of middlings.
1	pint of cod liver oil, or two pounds of cod liver meal.
4	pounds of fine oyster shell.
4	pounds of bone meal.
1/2	pound of fine table salt.

The cod liver oil is mixed with some corn meal and then sifted into the entire mixture. Mix this mash thoroughly.

Milk is given as drink.

Semi-solid buttermilk usually contains about thirty per cent. of solids. When fed as a drink, use about one and one-half pounds to each gallon of water.

If you desire to use dried buttermilk or skim milk, add about fifteen pounds to the above mash mixture, and give water to drink.

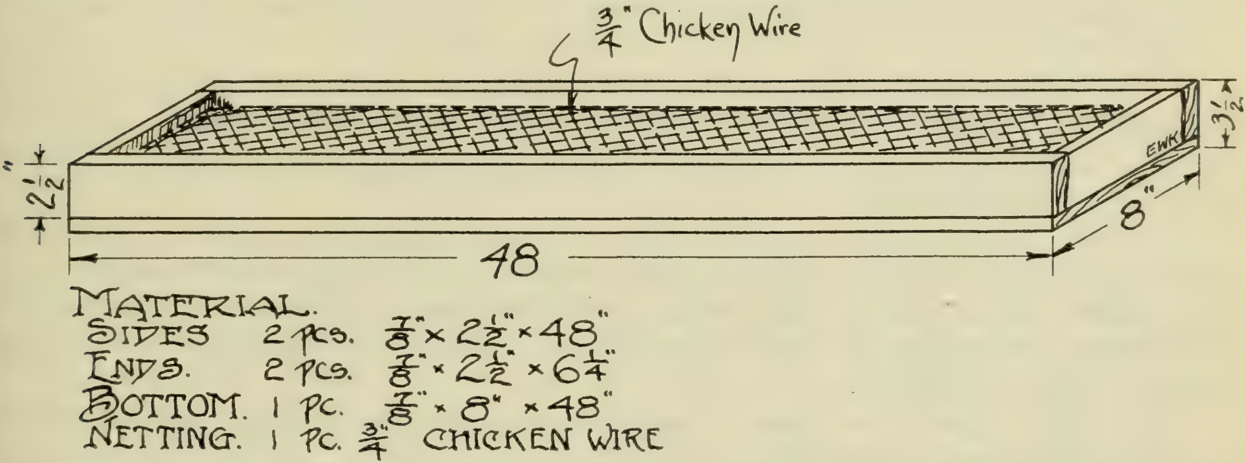
Use cut alfalfa as litter and renew it weekly, or else supply some kind of tender green feed.

The chicks are given the first feed about sixty hours after the hatch is completed.

For the first four or five days in the brooder they are fed five or six times daily.

Before putting the chicks in the brooder, fill the drinking fountain with milk or buttermilk. The milk should not be cold; the chill taken off is desirable. Use five or six drinking fountains to three hundred chicks. Place them around the hover about one foot out from the edge of the hover.

Place a little of the dry mash on boards, egg case flats or paper pie plates, etc. Leave the first feed before the chicks for from one-half to one hour. After the first feed, leave the feed boards down about one-half hour, and then remove them. This should be done about five or six times daily for the first four days. The following days, one can begin to leave the feed constantly in front of the chicks.



MATERIAL.
SIDES 2 pcs. 7/8" × 2½" × 48"
ENDS. 2 pcs. 7/8" × 2½" × 6¼"
BOTTOM. 1 pc. 7/8" × 8" × 48"
NETTING. 1 pc. 3/4" CHICKEN WIRE

Fig. 47. Plan showing construction of a home-made chick feeder for feeding dry mash to young chicks in the brooder.

It is a good plan to take the infertile eggs and boil them for at least thirty minutes. Then put them through an ordinary meat chopper. Once each day give a mash composed of equal bulk of eggs and dry mash, all the chicks will eat in fifteen minutes. Be sure to have enough feed boards so that every chick has a chance to eat. This feed should be given for at least one month, and may be continued, roughly, until the birds are ten weeks old.

No hard grain or scratch grain need be fed. The mash as outlined above is complete in itself, where cut alfalfa is used as litter.

Fig. 48. Brooding chicks, showing coal burning brooder stove and dry mash feeder in action.

Some additional green feed will be beneficial. That is a feed of lettuce, sprouted oats, minced potato peelings or cabbage is good. Immature, well cured clover hay, cut in about quarter inch lengths is a good green feed substitute. Where the chicks can get out on a good, clean, tender grass range, the conditions are ideal.

The above method of feeding can be used to broiler size, or for about ten weeks.

We usually continue this mash feeding until the chicks are broiler size. If the cockerels are to be marketed, more milk is fed. Five per cent. of dried milk or beef scrap is added to the ration, or about one pound of semi-solid buttermilk is given extra to each hundred chicks from the seventh week to broiler size.

The cockerels are separated from the pullets as they approach a weight of two pounds, possibly in many cases as small as a pound and a quarter. At this time we generally begin to feed some whole wheat and cracked corn. This is also fed from a hopper.

When the chicks are on range, the feed troughs or hoppers should be moved every few days. The ground near the feeders becomes filthy very quickly.

When the chicks are on range, the ration may be changed considerably. Where there is plenty of direct sunlight and tender green feed, it is only a waste to feed cod liver oil.

In many cases, the above feed mixture might be changed considerably, owing to local circumstances.

With March and early April pullets that were maturing rapidly, the milk could gradually be replaced with five per cent. of beef scrap (fifty per cent. protein) and the milk entirely eliminated.

The grain ration could be changed in the way that ground barley and rolled oats might replace the corn.

Gradually change the mash mixture to that used for laying hens. If pullets show signs of maturing too early, remove most of the protein source, such as meat scrap and milk.

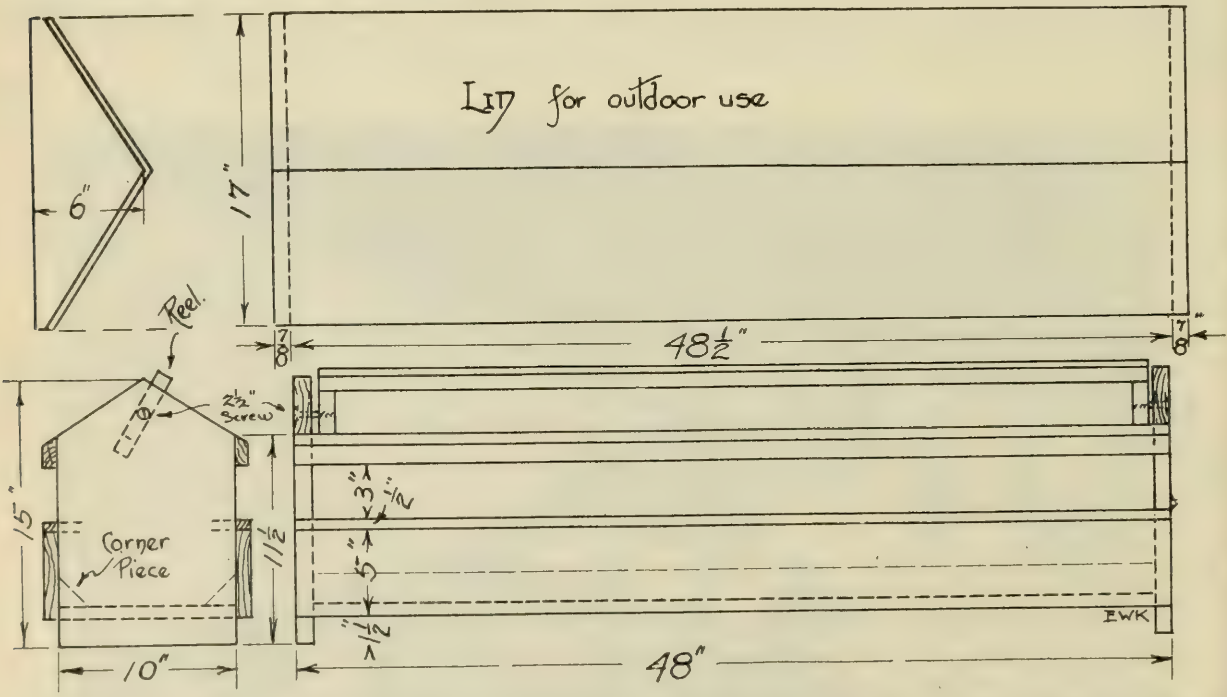


Fig. 49. Showing plans for the construction of a reel type of dry mash hopper. This is adapted for feeding of dry mash to growing chicks on range in whick case the lid is used. It may also be used for feeding dry mash to laying hens by removing the lid and inserting the reel.

Material for Mash Feeder:

Lid	2	pieces,	7/8″x 6″x 17″—Shaped.
	2	"	1/2″x 10″x 50¼″
Reel	2	pieces,	7/8″x 7/8″x 47¾″
	2	"	7/8″x 7/8″x 3″
Ends	2	"	7/8″x 10″x 15″
Bottom	1	piece,	7/8″x 10″x 46¼″
Sides	2	pieces,	7/8″x 5″x 48″
	2	"	7/8″x 1½″x 48″—Bevelled.
	2	"	1/2″x 2″x 48″
Corner pieces	1	piece,	2″x 2″x 48″—Cut diagonally.

FEEDING MOIST MASH TO BABY CHICKS

For years we have had success with a moist mash method of feeding baby chicks. This method entails more labour and system than does the dry method of feeding. Feed trials indicate that it will grow a chick a little faster, and the mortality is low.

Where one has had difficulty in rearing chicks, we would recommend the moist mash method.

Sixty hours after hatch is completed begin feeding. The first day, or the second day in the brooder, give from two to three feeds upon clean boards. A board three feet long and about four or five inches wide will allow, roughly, seventy-five chicks to feed. Use a little lime stone grit of small size, and about one ounce of dry mash mixture to sixty chicks. This ounce of feed is moistened with sour milk curds, or semi-solid buttermilk, and spread on clean boards. The boards are taken up and cleaned after each feed.

After this day, a regular schedule is followed:

Daylight	Mash,	moistened	with	sour milk curds.
9 a.m.	"	"	"	canned tomatoes.
11 a.m.	"	"	"	hard boiled eggs.
1 p.m.	"	"	"	sour milk curds.
3 p.m.	"	"	"	sour milk curds.
Night	"	"	"	hard boiled eggs.

Add a teaspoonful of cod liver oil to the tomatoes for each 500 chicks daily. Increase the amount gradually, but do not overfeed. Keep the chicks hungry, but give all a chance to eat.

On the second week in the brooder, place before them in a shallow box or other container. a mash, composed of the following ingredients:

700 pounds of corn chop.
500 pounds of shorts.
300 pounds of oat chop.
45 pounds of bone meal.
45 pounds of fine oyster shell.
80 pounds of alfalfa meal (omit this if there is plenty of tender green feed).
1 pint of cod liver oil to 100 pounds of feed.

The oil may be sprayed on, or to many it is easier to mix the pint of oil with some corn meal and then spread this through the entire mixture.

With the use of the self-feeders, the number of feeds may be reduced. There are two essentials to remember. The chicks should have one pound of semi-solid buttermilk to each four pounds of meal, and one pint of cod liver oil to each 100 pounds of feed.

Give the chicks all they will eat every night, after the first two or three days.

Tomatoes may be expensive to buy, if you have not home canned; but they put pep in the flock. Minced small potatoes, or peelings minced, are good once a day.

If you wish to give exercise, use a tablespoonful of commercial chick scratch grain two or three times a day to two hundred chicks. Scatter it in the litter.

There are many good feeds for baby chicks put on the market by various feed firms. When using these feeds, follow the directions as given. Do not change the feed, or method of feeding, before consulting the agent or manufacturer.

It is not necessary to feed much, if any, scratch grains; ground grains grow chicks a little faster than whole grains. Avoid, as far as possible, feeding on the ground. Where chicks are kept in large numbers the soil becomes filthy very quickly, hence it is a good practice to move the feed hoppers, drinking vessels, etc., frequently, and the colony house is better moved, if only twenty or fifty feet a few times during the season.

Care should be taken to have an abundance of green feed during the entire growing season, likewise the growing birds appreciate some shade. A corn field, an orchard or some such conditions makes an ideal range for the growing birds.

Where more than three hundred chickens are grown on an acre of land careful attention will have to be given to sanitation.

It is a good plan to have sufficient acreage so that chickens need not range over the same field more than one year in every two or three years.

If the pullets are developing too rapidly, decrease the milk and beef scrap in the ration and increase the hard grain.

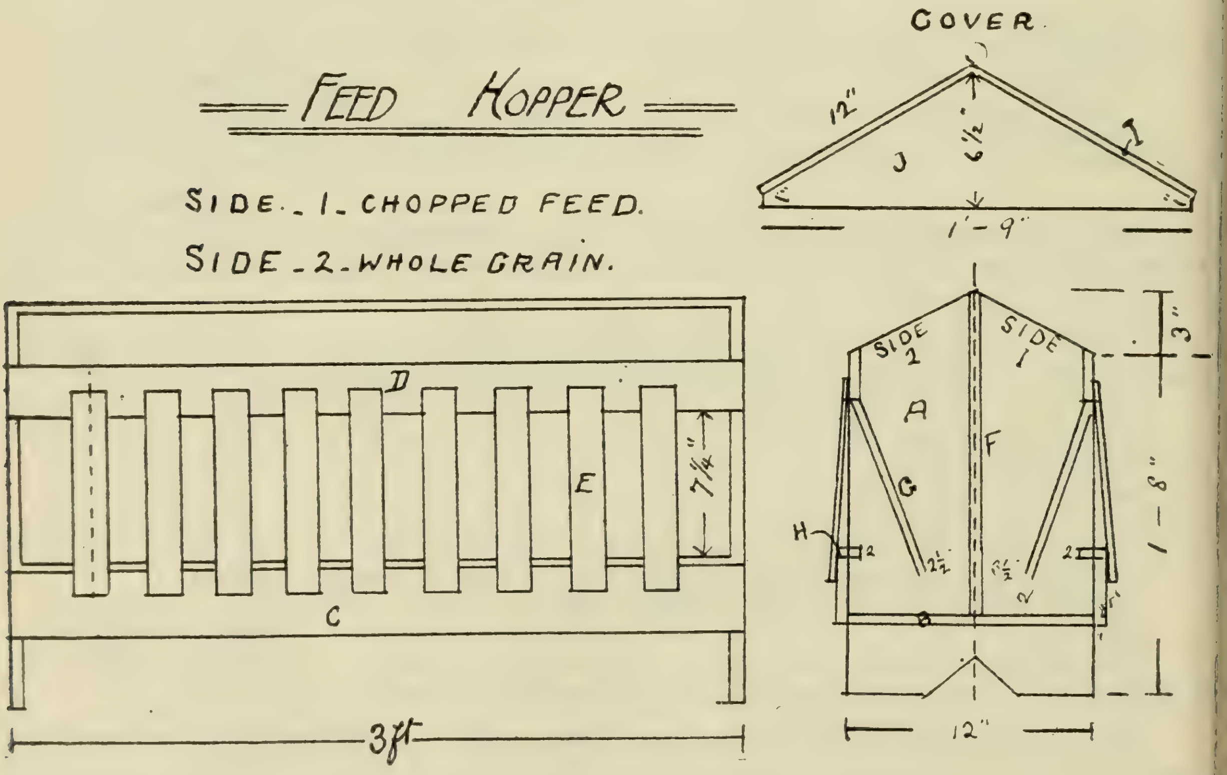


Fig. 50. Bill of Material.

A. 2 ends ⅞ x 12 in. x 1 ft. 8 in.
B. 1 bottom ⅞ x 12 in. x 2 ft. 10¼ in.
C. 2 sides ⅞ x 3¾ in. x 3 ft.
D. 2 sides ⅞ x 2½ in. x 3 ft.
E. 18 pieces ⅜ x 1⅝ x 10 in.
Side 1.—Chopped feed.

F. 1 division ½ x 16 in. x 2 ft. 10¼ in.
G. 2 divisions ½ x 9½ in. x 2 ft. 10¼ in.
H. 2 pieces ¼ x 1 in. x 3 ft.
I. 2 pieces ½ x 12 in. x 3 ft. 2 in. }
J. 2 ends ⅞ x 6½ in. x 1 ft. 9 in. } Cover.
Side 2.—Whole grain.

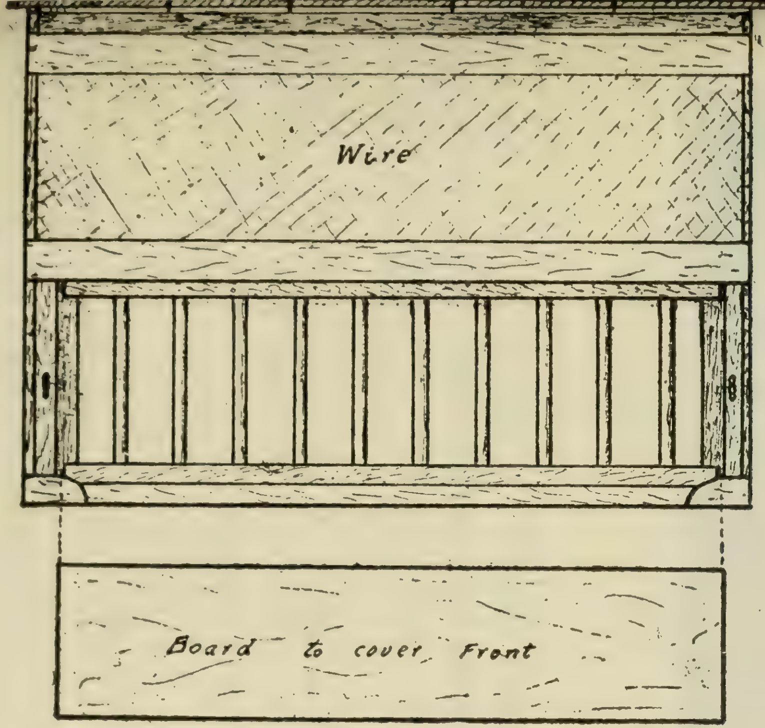


Fig. 51. Front of a convenient coop for hens and chicks.

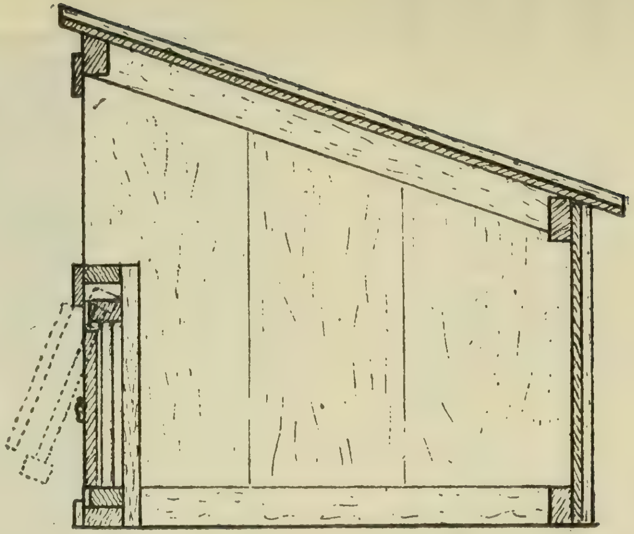


Fig. 52. Cross section.

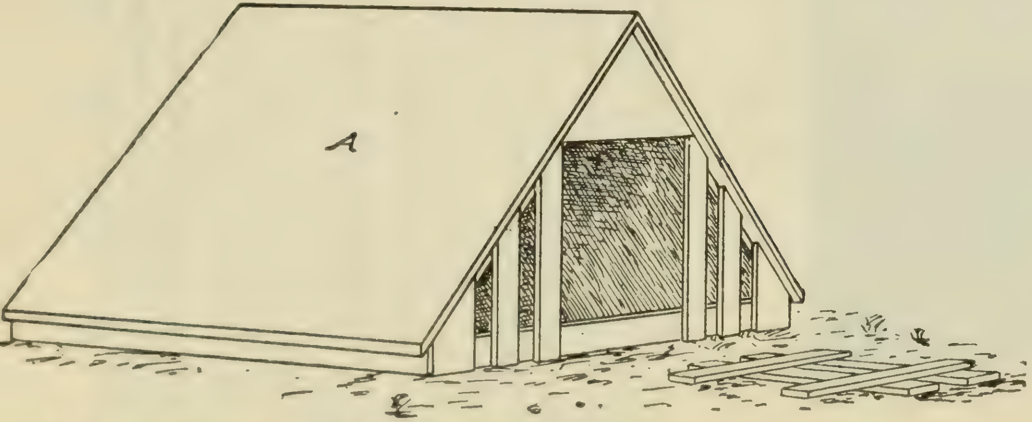


Fig. 53. Coop A—Each side of roof 24 in. by 30 in.; bottom 2 ft. 4 in.

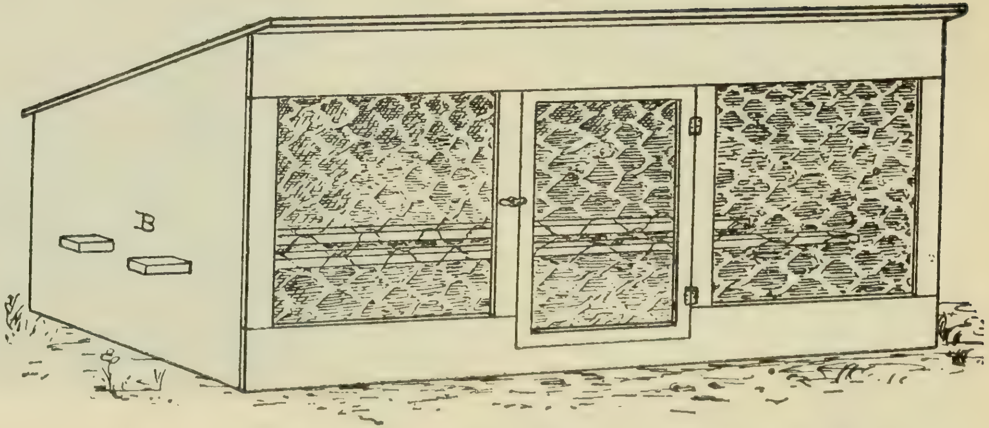


Fig. 54. Coop B—Length, 6 ft.; width, 2 ft. 6 ins.; height in front, 2 ft. 4 in.; height at back, 18 ins.

FATTENING CHICKENS.

Poultry fattening is now being done by many of the packing houses and by some growers. The bulk of the chickens are sent to market in rather a thin condition, or just as they come off the range.

The packers buy the chickens at a price that makes fattening profitable. The market for thin chickens is limited, hence the packer is forced to finish at least a portion of the birds. Certain districts within the Province have developed the finishing of poultry to a large degree. Where there is a good local market, or a number of buyers for finished birds, the growers finish the birds; but, where no discrimination in price is made in the sale of live birds, there is not much encouragement to fatten poultry.

Fig. 55. Producing two crops in one season—apples and chickens.

The usual time of feeding varies from two to five weeks. Unless there is a marked difference in price two weeks' feeding has been found to be the most profitable. With two weeks' feeding the birds should dress out (bled and plucked but not drawn), about ten per cent. more than their weight at the beginning of the feeding period. Some lots will not dress out much more than the original weight.

In large numbers birds lose from twelve to thirteen per cent. in bleeding and plucking. Numbers of trials of feeding indicate that a gain of from fifteen or more percentage should be obtained in a two weeks' feeding period. Some gains are much more, but on the average a gain of fifteen per cent. will be profitable.

It is not difficult to produce good chickens. Like other lines of live stock, the scrub sort are not desirable. Good, thrifty cockerels, either pure-bred, crosses, or grades of such breeds as Rocks, Orpingtons, Wyandottes, Rhode Island Reds, Game, Dorking, etc., make economical gains. It is usually not very profitable to feed Leghorns, Minorcas, or birds of a similar character.

These breeds make medium broilers, but rather poor roasters. The birds usually make the greatest gain when about three to four months of age, or at a weight of three and one-half to four pounds. Should the market demand a chicken of more than five and one-half pounds in weight, then it will be required to allow the birds to range longer, and the gain, in our experience, will be hardly as profitable, unless the price paid is higher at least one cent per pound.

The average birds make the most economical gains during the first two weeks of feeding. It does not pay to feed longer than three weeks, unless one is preparing birds for a specially select trade paying fancy prices.

Chickens can be taught to eat by lamplight, and where one's time during daytime is otherwise occupied, this feature is very convenient. After November first, or even earlier, we feed but few chickens during daylight. They are generally fed twice each day, and not more each time than they will consume quickly.

CONSTRUCTION OF FATTENING CRATES.

Fattening crates are usually made seven feet six inches long, eighteen to twenty inches high, and eighteen inches wide. The crate is divided into three compartments, each holding from four to five birds, according to the size of the chicken.

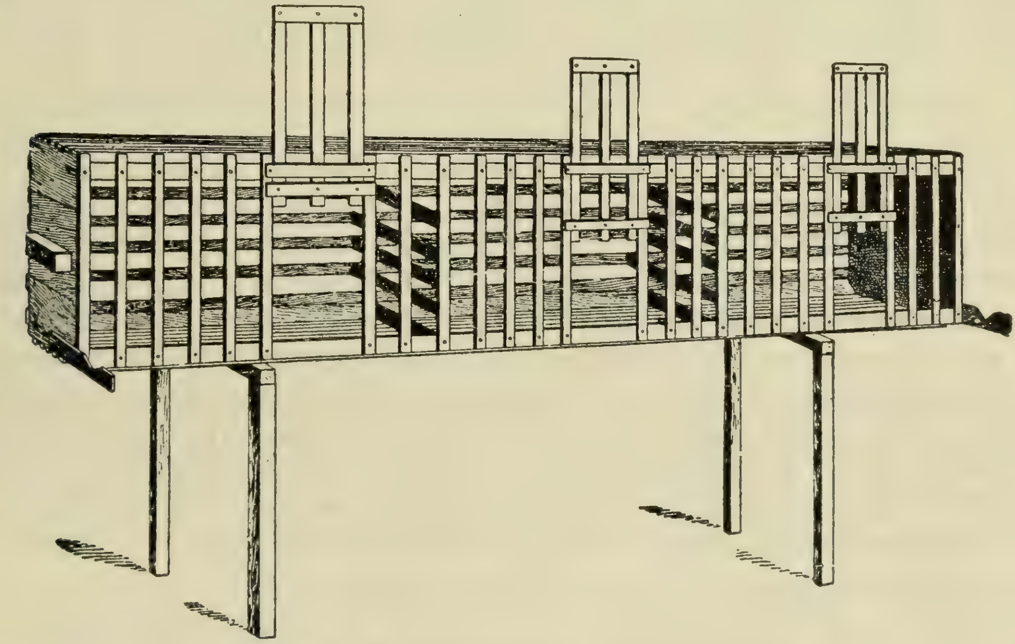


Fig. 56. Showing a Single Crate or Coop.

The crate is made of slats, except the ends and partitions between the compartments, which are solid wood; those on the top, bottom and back running lengthwise of the coop, while those on the front run up and down. The slats are usually one and one-half inches wide and five-eighth inches thick. Those in front are placed two inches apart to allow the chickens to put their heads through for feeding. The slats on the bottom are placed about three-quarter inches apart, so as to admit of the droppings passing through to the ground. Care should be taken not to have the first bottom slat at the back fit too closely against the back. An opening between the first slat and the back prevents the droppings from collecting and decomposing. The slats on the top and back are usually two inches apart.

There is a small V-shaped trough arranged in front of the coop for feeding and watering the chickens. This trough is from two to three inches deep, and is generally made of three-quarter-inch lumber.

Very fair coops may be made from old packing boxes, by taking off the front and bottom and substituting slats in their places. (See Fig. 56.) During warm weather these crates may be placed out of doors. They need to be protected from the rain, which is easily accomplished by placing a few boards over them. In cold weather the crates should be placed in a house or shed where they are protected from raw, cold winds. When fattening chickens inside of a building, it is well to darken the building and keep the birds as quiet as possible.

After each lot of birds is killed, we paint the crates with some liquid lice-killer. Coal-oil and carbolic acid is very good. Use one gallon of coal-oil to one pint of crude acid. We have used some of the prepared mixtures with good results. If the birds (bought from different parties) are very lousy when put up, they should be well dusted with sulphur or good insect powder. The birds should be watered at least twice every day in warm weather. Grit should be given them twice a week.

During the first week feed lightly—never quite all the birds will eat. We prefer feeding twice a day during the entire feeding period. Chickens weighing from three to three and one-half pounds each that are thrifty and of good breeding, appear to be the most profitable for feeding. Large chickens, weighing from five to six pounds, gain less and eat more than the smaller ones.

Should a bird become sick while in the crate we find that if it is given a teaspoonful of salts and turned out on a grass run it will usually recover.

CRATE FEEDING *vs.* LOOSE PEN FATTENING OF CHICKENS.

The term "fattening of chickens" has been in use for some time, but it does not exactly convey the meaning intended by the feeders of chickens. The object is to make the chickens more fleshy, with just sufficient fat to make the chicken cook well. The chickens are not intended to be abnormally fat, yet at the same time they carry considerable fat well intermixed with lean meat.

We have for a number of years conducted experiments with chickens in crates and in loose pens. We have tried about six different feeders and the results vary. With some feeders we had equally as good results with birds in crates as with those in loose pens. We have tried two feeders in particular who could not feed birds to advantage in loose pens as compared with crates. We have had one feeder who could get slightly better returns in some cases, not all, with birds in pens as compared with crates.

The majority of buyers seem to think that the crate-fed birds are much superior to those fed in loose pens. Personally we would prefer feeding birds in crates, for the reason that it takes less room, and we believe that we can feed them with less expenditure of labour and get a more even product. There are now many people who can get good results from feeding birds in box stalls, etc. No matter which method is followed, cockerels should be fed for two weeks or more before they are killed and sold.

HOW TO FEED.

We receive a number of inquiries as to how we feed the birds that are being fattened. Most inquirers wish to know the exact amount fed each day.

It will be noticed that we fed very lightly at the beginning—a very important point—and that the amount was gradually increased until such times as the birds refused to eat all that was given them. No feed was left in front of them longer than ten minutes after it was placed in the trough. Any feed left after such time was removed.

Table showing amounts fed morning and evening to two lots of four birds each. The first lot shows steady increase in amount fed, while the second shows irregular increase.

	LOT No. 1				LOT No. 2			
Dates	Morning		Evening		Morning		Evening	
	Meal	Milk	Meal	Milk	Meal	Milk	Meal	Milk
Oct. 10	.......oz.	.......oz.	4.25 oz.	6.25 oz.	.......oz.	.......oz.	5.0 oz.	7.5 oz.
“ 11	5.0 “	7.5 “	5.5 “	8.25 “	5.0 “	7.5 “	6.0 “	9.0 “
“ 12	6.0 “	9.0 “	6.5 “	9.75 “	6.5 “	9.25 “	6.0 “	9.0 “
“ 13	7.0 “	10.5 “	7.0 “	10.5 “	6.0 “	9.0 “	5.5 “	8.25 “
“ 14	7.0 “	10.5 “	7.0 “	10.5 “	6.0 “	9.0 “	6.5 “	9.25 “
“ 15	7.5 “	11.25 “	7.5 “	11.25 “	6.0 “	9.0 “	5.5 “	8.25 “
“ 16	7.75 “	11.75 “	7.75 “	11.75 “	6.0 “	6.0 “	6.0 “	9.0 “
“ 17	8.0 “	12.00 “	8.25 “	12.00 “	6.5 “	9.25 “	7.0 “	10.5 “
“ 18	8.5 “	12.25 “	8.75 “	13.00 “	8.0 “	12.0 “	8.0 “	12.0 “
“ 19	9.0 “	13.50 “	9.25 “	14.00 “	8.0 “	12.0 “	9.0 “	13.5 “
“ 20	9.5 “	14.25 “	9.75 “	15.75 “	10.0 “	15.0 “	10.0 “	15.0 “
“ 21	10.0 “	15.00 “	10.25 “	15.25 “	10.0 “	15.0 “	9.0 “	13.5 “
“ 22	10.5 “	15.50 “	10.75 “	16.00 “	9.0 “	13.5 “	9.0 “	13.5 “
“ 23	11.0 “	16.50 “	11.25 “	16.75 “	10.0 “	15.0 “	8.0 “	12.0 “
“ 24	11.25 “	16.75 “	12.00 “	18.00 “	10.0 “	15.0 “	10.0 “	15.0 “

It is difficult to give a ration suitable for fattening chickens and that meets the requirements of every individual. Many of us have to use whatever feeds are available, and for that reason we are giving several rations that have worked fairly well with us in a general way. It may be said that the grains in a ration should be ground as finely as possible, and further, some grit should be fed to the chickens at least once a week, and it is also desirable that the feed should be mixed to the consistency of a pancake batter, so it will pour; and moreover, the best results are secured when the feed is mixed twelve hours previous to feeding.

The best ration that we have yet used is one composed of two parts of finely ground oats, two parts of finely ground buckwheat, and one of finely ground corn; to this is added sufficient sour milk to make a batter or ordinarily about two to two and one-half pounds of milk to one pound of grain. We have gotten very good results from a ration composed of equal parts of corn meal, middlings, and buckwheat meal. Frequently barley meal can be substituted for the buckwheat, or oat meal for the middlings. It is desirable, if possible, to always use milk, as much better gains are made with it than any other feed. Where milk is not available, blood meal and beef scrap can be substituted, but we would not advise more than fifteen per cent. of the grain ration to consist of these feeds. We would advise soaking the blood meal or beef scrap in warm water for twelve hours previous to being mixed with the grain. We have gotten better results in some cases and equally as good in all cases by feeding any of the above mixtures cool or cold rather than warm—that is to say, there were no better gains made by keeping the feed at seventy or eighty degrees than at thirty-five or forty.

It is of the utmost importance that the birds be kept with keen appetites, as a little over-feeding on the commencement usually means indifferent gains. One should be careful to have the birds free from lice or other insects, and as far as possible to keep them in a cool, comfortable place, rather secluded, so as not to be disturbed by the visiting public or other chickens. The birds should be dusted with a small amount of sulphur or other insect powder in order to keep the lice in check. If the sulphur is used too freely it produces a scaly appearance on the birds when dressed.

KILLING AND DRESSING POULTRY.

All birds should be fasted for twenty-four hours before killing, and during the period of fast given some water to drink. If this is not done, the feed remaining in the crop and intestines at the time the bird is killed, decomposes. As a result of this decomposition of feed in the digestive tract, strong-smelling gasses are liberated which taint the flesh of the bird, not only destroying the flavour, but very much lowering its keeping qualities.

All birds should be killed by bleeding, preferably through the mouth. This is a very simple operation, and a little practice will ordinarily make one fairly handy at this work. Two general positions for the bird during the operation are used. The one is to place the bird on a padded bench or table, and the other is to hang the bird up by the feet with a rope or cord. For the average person the latter method is preferred, as there is less danger of bruising or barking the skin than where the bird is lying upon some object. The one end of rope or

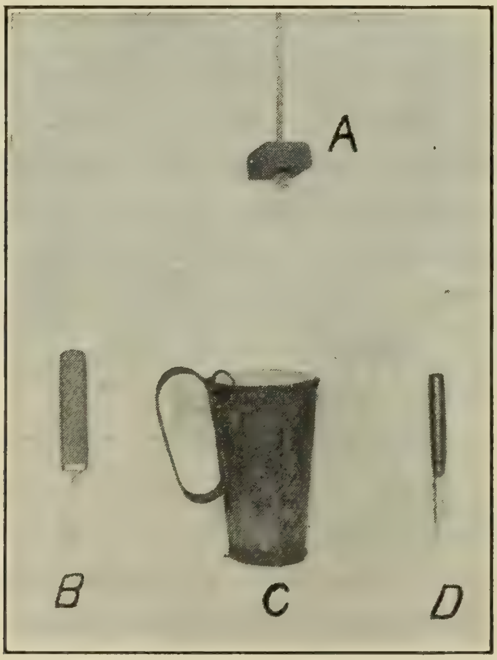


Fig. 57. A. Rope and block for hanging bird up with. B. Killing knife. C. Blood can. D. Pinning knife.

cord may be fastened to a small rod or pole and to the other end attach a small block about two inches by two inches as shown in Fig. 57. When hanging the bird up, the end of the rope with block on is placed around the feet and the block dropped in between the bird's feet and rope. This holds bird without tying, and should be so adjusted that bird's feet are about on a level with the picker's shoulders.

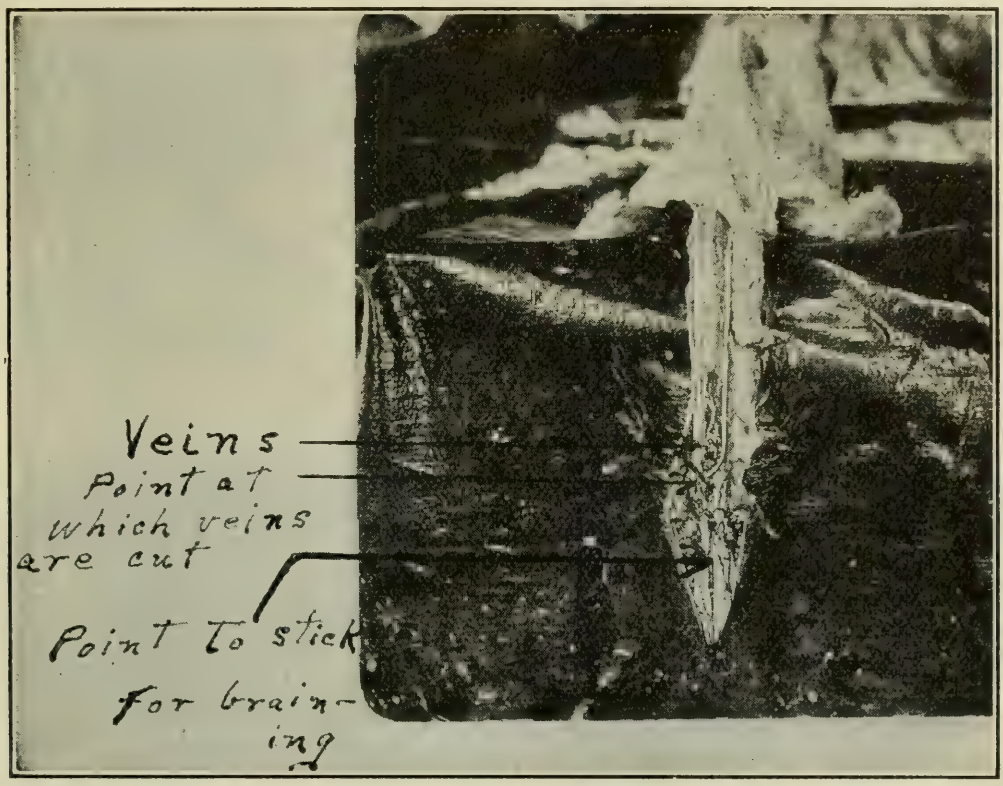


Fig. 58. Cut showing location of veins and point for sticking brain.

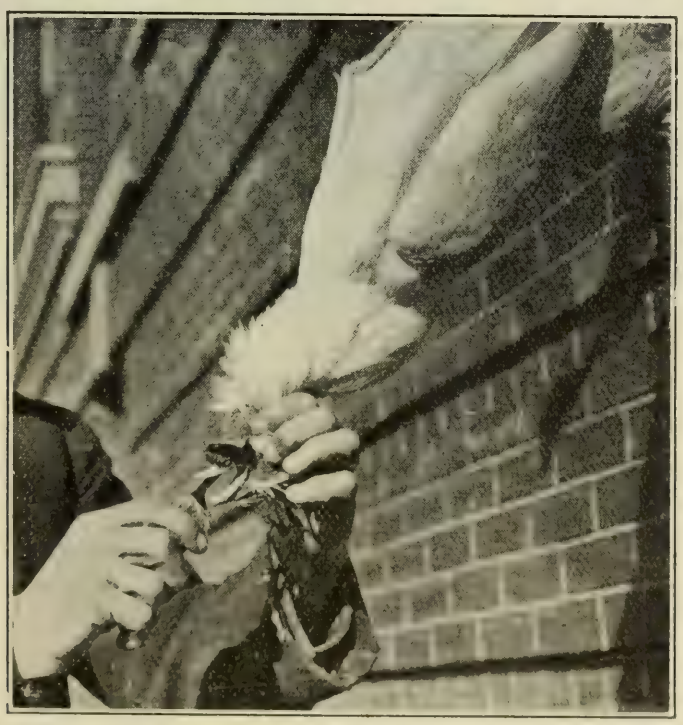


Fig. 59. Bleeding Operation.

For bleeding a sharp knife with a blade about three inches in length will answer. A regulation killing knife is shown in Fig. 57. To bleed, catch the bird's head with the thumb and forefinger just at the juncture of the neck and head or at the ear-lobes, as shown in Fig. 59, then with the third finger open the chicken's mouth. Next insert the knife and put it down the throat practically the length of the blade, then with the edge of the blade turned down, cut rather heavily with a drawing stroke of the knife. The object is to sever the jugular veins at the point where they unite back of the head, as shown in Fig. 58.

The bird should bleed freely if the cut is made at the proper point. Next, turn the blade of knife over and insert the point of blade in the slit or groove in roof of mouth, as shown in Fig. 58, and then quickly push backward so as to pierce the brain. If the back of the knife is kept on a line with and touching the point of the bill, the blade will pierce the brain. One can tell when this is done as the chicken will squawk. If the bird does not squawk the brain is not pierced, which means tight feathers and hard picking. As soon as the sticking operations are completed attach a blood-can to the lower bill. This catches the blood, thus preventing it being thrown about, and the can being weighted tends to hold the bird still. For a blood-can, any can which is small and to which a small hook can be attached will answer the purpose. In Fig. 57 is shown a style of blood-can which is used extensively in packing-houses. In this can the hook is solidly attached on the inside of the can near the handle. The weight in can is provided in the form of three-quarter inch of lead in the bottom. Cement or a small stone will answer the purpose equally as well.

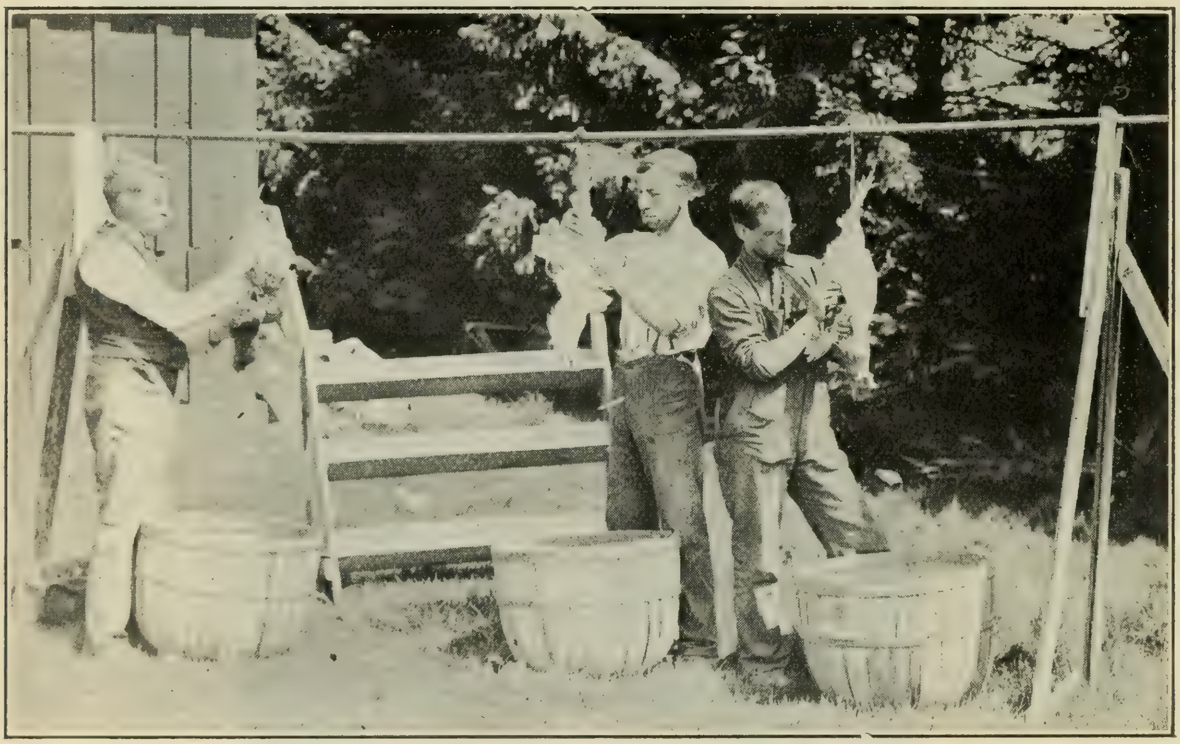


Fig. 60. Killing and Plucking Chickens.

The chicken should be plucked immediately, first removing the long wing feathers and tail feathers, then each side of the breast, then the legs, and lastly the back. Do not try to pull the feathers either forward or backward, but more sideways or at an angle. The rough or coarse feathers should be removed in the shortest time possible, as the more quickly the feathers are removed after sticking the easier they will come and the less danger there is of tearing the skin. For instance, in removing wing feathers grasp both wings in the left hand and the feathers of both in the right, removing them all at one stroke of the right hand. Next, raise the right hand to the tail, grasping all the feathers in the tail, and with a slight twist remove with a second stroke of the right hand, and so on over the different sections of the body. To remove the pin feathers use a dull, round-bladed knife, similar to an ordinary paring knife. (See Fig. 57.) Be careful not to rub or bark the skin. This may be done very easily by rough handling, or by placing the chicken in contact with coarse clothing, hence do not put chicken on your lap to pluck it. If you should, unfortunately, tear the skin, hold the skin at the torn part tightly to the body between the thumb and first finger, and then remove the rough feathers near torn part. Anyone with a little practice can remove the rough feathers in from three to five minutes. Expert pickers will do it in from three-quarters of a minute to one minute.

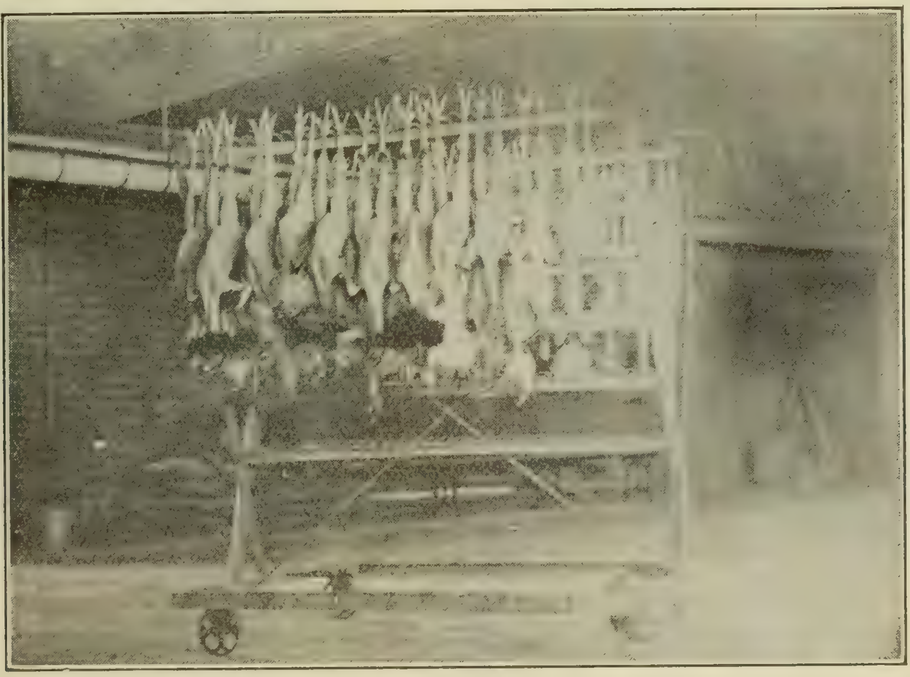


Fig. 61. Cooling Rack.

The bird should be plucked clean, the blood washed from the head and out of the mouth and the feet washed clean.

The cooling rack allows free circulation of air around the birds, resulting in more rapid cooling, which on large packing plants is very important, and hence we find the cooling rack in common use in such places.

Many good chickens are spoiled by being packed before they are thoroughly cooled. Care should be taken that all the animal heat is out of the body before the birds are packed. We find it advisable to cool the birds at least twelve hours before packing them.

In packing birds for shipping, they should be packed in boxes holding one dozen birds to the box. The size of the boxes varies with the grade or size of chickens packed in them, but should be such that when chickens are packed they are absolutely tight, so that there is no possibility of them shaking about, and becoming bruised. The boxes are best made of basswood or similar wood, free from odour, as otherwise the flesh of the birds will absorb the odour, thereby tainting the flesh. The box is lined with parchment paper, and, if the chickens are to be shipped a long distance, each bird is wrapped in parchment. This prevents the chickens bruising each other, and, at the same time, to a considerable extent, checks decomposition. Do not use ordinary wrapping paper, as it draws dampness and will cause the chickens to become clammy, which makes them more or less unsaleable. Fig. 62 shows one method of packing in common use, and is termed the "side pack," i.e., the birds are so placed in box as to show the entire side.

The dimensions of some of the boxes are: for broilers, weighing about twenty-four pounds per dozen, sixteen inches by fifteen inches by three and one-half inches inside. This is where they are packed in single layer, with the breasts up and the legs extended. For chickens weighing thirty-six to forty-two pounds per dozen, a box twenty-three inches by fifteen and one-half inches by four inches inside would do. One dozen roasters, weighing four to four and one-half pounds each, a box thirty-two inches by nineteen inches by four inches inside. For heavy roasters, weighing five to five and one-half pounds each and packed single layer, a box thirty-three inches by twenty inches by four and one-quarter inches inside measurement. The material used varies in thickness from one-quarter inch for sides, bottom, and top, and one-half-inch for ends in the smallest size boxes to one-half inch for sides, top and bottom, and seven-eights inch ends in the largest boxes.

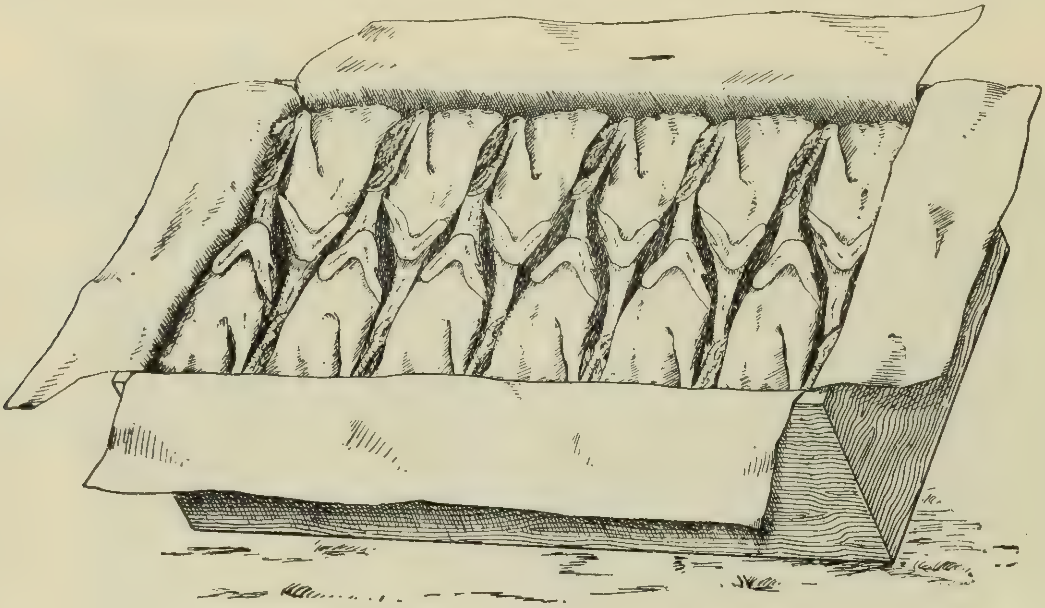


Fig. 62.

(The writers wish to acknowledge the use of *Poultry Packers' Guide* in preparation of box dimensions above stated, for which credit is hereby given.)

POULTRY AND EGGS FOR MARKET.

The profit from poultry and eggs depends upon the cost of production and the selling price. The last few years have seen very good markets and fairly high costs and, upon the whole, poultry have paid well. The farmers are taking more interest in this branch of the business and more poultry farms are successful.

During the past few years there has been a good export business in eggs in particular, which has meant very good local markets. Our export regulations require eggs to be exported on grade, with the result that most of the low grade eggs have been thrown on the local markets. This condition has created a demand among certain sections for the best grades for home consumption. It is evident that these conditions in general point towards the sale of eggs for home consumption on a graded basis.

The only fair method to the producer and the consumer is the purchase and sale of eggs on a graded basis. The producer of a first-class product should get the best price, and the consumer should know what he or she is buying.

Poultry and eggs are good food. For some unknown reason the average Canadian does not consume very much poultry meat. The average person, we think, should eat at least one egg each day.

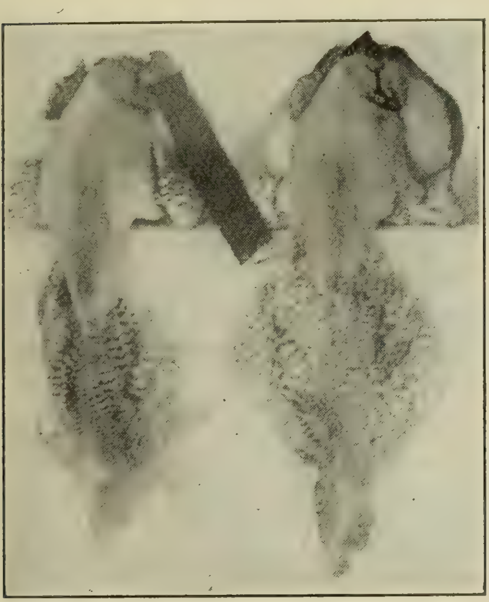


Fig. 63.

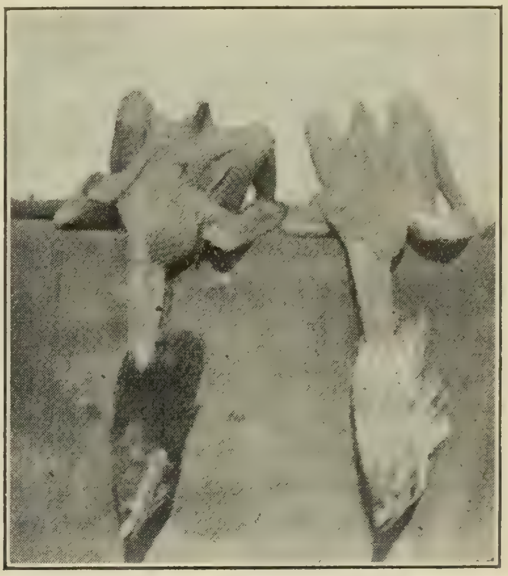


Fig. 64.

Showing Good (63) and Poorly-fleshed (64) Birds.

In the producing sections situated away from the centres of consumption the selling of the produce for its value is a problem. There are two things that would assist in solving this problem. One would be for the buyer, whether dealer or grocer, to buy the produce on the quality payment basis; and the other is selling through co-operative organizations. Which is the better method depends entirely on local circumstances. A co-operative society situated away from large local markets, when well managed, should be the better method; on the other hand, payment on the basis of quality is simple and just. These problems can be best solved by the producer and dealer getting together. Co-operative buying and selling is the ideal method, but everybody must work together and stay with association. It is seldom that a co-operative society or joint stock company does not have poor years and unsatisfactory conditions. Success depends on united effort.

There appears to be a general idea that the shell of an egg protects the contents against all kinds of germs and weather; that the outside of the shell may be filthy, but that the interior is not in the least affected by the filth on the outside.

There is nothing more disgusting at the breakfast table than to break a bad egg. No more eggs are wanted for days, perhaps for weeks, and consequently egg consumption decreases; or eggs are looked upon as a doubtful source of food. Many bad eggs are due to ignorance on the part of the producers and consumers, and many dealers are as careless in their methods.

The shell of an egg is porous, or is full of very small holes. The egg is designed to hatch a chick. The chick under favourable conditions grows inside the shell, and finally bursts it open. The holes in the shell supply the chick with air as it grows, also allows the bad air to escape. Science has proved this, but we have ample illustration in practical work. Eggs that become badly smeared with broken eggs in the nest during incubation usually rot, owing to the breathing holes becoming plugged or blocked by the broken egg content. Greased eggs will not hatch for the same reason; and we might mention several other examples.

Knowing that the shell is porous, we can readily understand how minute animal or plant life, or germs, may enter the eggs. Let us take a common case of mouldy or musty eggs. Frequently the paper fillers of egg boxes will become damp due to the boxes being left in a shower of rain or something of the kind. The fillers are only slightly damp, and we think they will do. If no eggs are put in the boxes, and the boxes with fillers are set aside for, say, a week or so, when they are opened they smell musty, and if the fillers are examined we will see slight developments of mould here and there. Now in cases where eggs are put in such fillers they soon become musty, and when they are left in for some time they become mouldy, not only on the outside of the shell, but on the inside as well. The writers have taken clean eggs on the day they were laid, and put them in dry paper boxes which were slightly mouldy, and set them aside in a dry cellar for a period of a few weeks, and at the end of this time many of the eggs had well-developed mould on the inside of the shell.

Many eggs are spoiled by being partially incubated. Most people believe that an egg must be set under a hen, or put in an incubator before it will start to hatch. Eggs will start to hatch at less than ninety degrees of heat. Many eggs are submitted to this or higher temperatures for several hours, if not days, before reaching the consuming public. When the germ inside the egg commences to develop, the edible qualities of the egg are lessened, or the egg goes off flavour. Eggs may be kept at an incubating temperature for a day, when the chicks will start growing; next day the temperature may be so low that the chick is killed, and from that point decomposition begins, possibly slowly, but, nevertheless, the egg is gradually going bad.

There are almost innumerable ways in which eggs may start hatching during the summer, such as forgetting to gather the eggs daily, and leaving some under broody hens over night, leaving them exposed to the sun or in warm rooms, stores, cars, etc., or even in the kitchen cupboards.

No one can guarantee eggs to their customers during warm weather unless the males are removed from the flock. Unfertilized eggs are essential. We may at home take every precaution, but who knows where or how the cook may keep those eggs, even after they have passed from the dealer's hands. The allowing of males to run with the hens all summer costs the Ontario growers a large sum of money. The writers have stood by candlers in a large packing house, and seen over twenty of the thirty dozen eggs in a case that were more or less incubated, most of the eggs being about forty-eight hours on in incubation. The dealer is thus forced to make prices to meet this shrinkage; at times the public may get "bargain" eggs.

Filthy eggs, or even washed eggs, may be decomposed or rendered useless from the germs in the filth on the eggs. Washed eggs, if used immediately, are good, but they deteriorate very quickly after washing.

Flavour of Eggs.

Many of us forget that eggs will absorb odours. They will not absorb odours as readily as milk, but, at the same time, care should be taken in keeping the storage room for eggs free of strong odours. For instance, to put eggs alongside of onions, turnips, or similar strong smelling foods would mean that the eggs would absorb more or less of these flavours.

Again, the feed that a hen consumes very materially affects the flavour of the eggs. This can be very easily demonstrated by feeding mostly scorched grain, or giving large quantities of pulped onions in a mash feed. One demonstration will convince anyone that eggs have been scorched, or taste of onions no matter how cooked.

When hens get but little grain feed during the summer and are forced to hunt for their living over manure piles, and catch insects, the yolk will become almost red in colour. These eggs make the consumer remark that winter eggs taste better than summer eggs. Frequently feeding as above produces a thin, watery white, and the egg has not only a bad flavour, but has poor keeping qualities, and, moreover, is little better, if as good, as a fair pickled or cold storage egg.

POULTRY HYGIENE AND SANITATION.

There is very great doubt in the minds of the writers of the advisability of "doctoring" sick chickens. The unit of production (the individual bird) is so small that if a man's time is worth anything it will not pay him unless he considers the bird especially valuable. The "cured" bird will always remain a menace to the flock, and with the slightest adverse conditions will show a return of the disease. Disease of any kind usually weakens the constitution of the individual, and hence lowers their breeding value. In such simple diseases as indigestion, colds, etc., where the greater part of the flock is affected and the flock can be treated as a unit, treatment is, no doubt, advisable. Where the birds are kept for the production of eggs and meat only, the hatchet will be found the safest and most effective method of treatment for individuals.

Prevention is better than cure, and every effort on the part of the poultry keeper should be exerted to maintain such environmental and sanitary conditions as to prevent disease gaining a foothold in the flock.

The stock which is used for breeding purposes should be selected first for *constitutional vigour*, as this is the foundation upon which the breeder must build future success. Discard all birds that have at any time been sick, and cull very closely birds which, as chicks, were raised in closely confined quarters.

The housing of the birds is very important in the prevention of disease. Abundance of fresh air and sunlight in the house, without draughts or dampness, will do much in maintaining a healthy flock. Houses must be kept sanitary by frequent removal of droppings and litter, as the latter becomes soiled. At least once during the year, preferably about the the month of August, the house should be thoroughly cleaned and disinfected. All movable fittings, as nests, hoppers, and roosts may be removed from pen to facilitate cleaning. Thoroughly scrape dropping-boards, if used; remove all litter from floor, and then brush down ceiling and walls with a broom. The house is now ready to be disinfected. The writers find it advisable to apply a coat of whitewash to all pens once a year to brighten and help cleanse the pens. They have also found it most economical to combine the whitewashing and disinfecting processes by adding the disinfectant to the whitewash. The whitewash is made by slaking fresh stone lime and adding sufficient water to dilute to a creamy mixture. To this is added ten to fifteen per cent. of crude carbolic acid or some of the tarry compounds used for disinfecting purposes, and the whole applied with a hand spray pump. A pump capable of developing a fair amount of pressure is desirable, as it forces the solution into all cracks and crevices about the building. Applying with a whitewash brush is not to be recommended, as there is not sufficient penetration. Such materials as salt and cement, which are used by some to give sticking power to the wash, are not here used. Nests, roosts and other movable fittings are best treated by dipping in solution of the wash or may be sprayed, but the dipping is to be preferred. Be sure to strain all whitewash before using in spray pump.

The land upon which birds are running must receive close attention in order to keep it clean and sanitary. Constant ranging over a piece of land by birds tends to foul the land, making it "chicken-sick." The heavier the soil the more serious is the trouble. Aim to cultivate the run or yard at least once in the year and grow a crop of grain or rape on it. This tends to cleanse the soil of droppings and at the same time produces succulent green feed for the birds.

The feed must be closely attended to and no feed given the birds which is musty or mouldy or where putrefaction has started. Only the purest and most wholesome feeds should be used, or they will not only have an ill effect on the health of the birds, but seriously affect the produce from the flock.

Exercise is very essential to health, and this applies to chickens just as much as to other classes of stock. This is very important in the winter months, especially if one wishes to secure good hatches of strong, vigorous chicks.

In case of sickness, isolate all sick birds from the flock and either treat or destroy. All dead birds should be disposed of by burying deeply (two to three feet) or burned: the latter is the safer method of disposal.

Birds which are badly infested with vermin, such as lice or mites, will not thrive. If the vermin are not kept under control they will in time become so bad as to seriously lower the vitality of the birds, thus rendering them more susceptible.

WHITEWASHES FOR FARM USE

E. W. Kendall, B.S.A., Department of Farm Mechanics

Whitewash has a wide application to farm use and deserves a much greater popularity than it at present enjoys. Its ingredients are inexpensive and readily obtained; it is not difficult to make and it is easy to apply it. In addition to these advantages, it protects the surfaces to which it is applied, brightens up dark interiors and is sanitary. A fact not generally known is that whitewash may be coloured provided that light tints and shades are used and that the pigments are not affected by lime. Among such are yellow ochre, raw and burnt amber and raw and burnt sienna.

Preparation of the Surface.—The surface to be whitewashed should be just as clean as one that is to be painted and it is a first essential to good results that all dirt, dust, grease and scaley material be removed before there is any attempt to apply the wash. This implies a liberal use of scrapers and stiff brushes. When the cleaning is finished and the surface dusted, it is well to dampen it slightly just before applying the wash.

Application of Whitewash.—Whitewash may be applied with the brush or sprayer. In applying with the brush use one at least four inches wide and work rapidly making no attempt to "brush out" as in painting. Let the coat be fairly thin and transparent and it will be opaque when dry. The small hand sprayers sold by the seed firms may be used. These will cost around $10 and should be of brass if you expect them to last for a number of years. In using sprayers it is quite necessary that the wash be strained through at least two thicknesses of cheese cloth. Spraying has many advantages over brushing under certain conditions and it forces the material into cracks and crevices that would not be reached by the brush. In using the sprayer always hold the nozzle so that the wash is applied at right angles to the surface; this gives even application. The sprayer should be thoroughly cleaned after use and especially the nozzles as a small particle of dirt clogging one side of the nozzle will cause it to send out a lop-sided stream and the work will be patchy.

Estimating Quantities.—In estimating the quantity of material required many problems and conditions are encountered, but the following general figures may be used as a basis. One gallon of whitewash will cover approximately 225 square feet of wood, 180 square feet of brick and 270 square feet of plaster. Using a 4-inch brush a man will cover 200 square feet of ceiling, 200 square feet of rough wall or 350 square feet of smooth wall in one hour.

EXAMPLE.—Basement 36′ wide x 60′ long x 9′ high.
Distance around walls is 192 feet.
Area of wall is 192′x 9′ = 1,728 square feet.
Area of ceiling is 60′x 36′ = 2,160 square feet.
Total area.............. = 3,888 square feet.
225 square feet require 1 gallon.
3,888 square feet require 3,888 divided by 225 = 18 gallons approximately.
200 square feet are covered in 1 hour.
3,888 square feet are covered in 20 hours.

NOTES ON THE PREPARATION OF WHITEWASH

(*a*) Prepare the lime and water paste a few days before you wish to use it.

(*b*) Where casein, glue or formaldehyde are to be used, the solutions must be brought together only when they are *quite cold*. This is very important.

(*c*) The solutions mentioned in (*b*) should be added *quite slowly* and at the same time they should be stirred vigorously and constantly.

(*d*) In no case should you mix more of the wash in one day than you can use in that day when any of the solutions mentioned in (*b*) are used.

(*e*) Skim milk may be used as a substitute for casein but it is not quite so effective.

(*f*) In place of one sack (fifty pounds) of hydrated lime, you may use the paste made by slaking one-half bushel (thirty-eight pounds) of fresh quick-lime with about six gallons of water. This slaking is sometimes done by placing the quick-lime in a barrel and adding the water boiling hot. If cold water is used the water may be added a little at a time stirring each time; when heat ceases to be given off the lime is slaked.

Before using, strain this paste through a fine screen.

(*g*) Molasses is said to render the lime more soluble and to give it greater penetrating power. Use in proportion of one pint of molasses to five gallons of the wash.

(*h*) Alum tends to prevent rubbing and is used in proportion of one ounce to one gallon of the wash. It would not be needed in the formulae C, D or E given below.

(*i*) If a gloss is desired, dissolve one pound of bar soap in a gallon of boiling water and when it is cold add it to five gallons of the thick wash.

SOME COMMON FORMULAE

A. 1. Dissolve fifteen pounds of common salt in seven and one-half gallons of water.
   2. *Slowly* add one sack of hydrated lime, *stirring vigorously*.
   3. Thin this to a milk like consistency with water.

B. 1. Make a paste of one sack of hydrated lime and seven gallons of water.
   2. Dissolve one pound of common salt and one-half pound of zinc sulphate in one gallon of boiling water. Allow this to cool.
   3. Pour this last solution into the lime paste solution a little at a time, stirring vigorously.
   4. Stir in two gallons of skim milk.

C. 1. Soak five pounds of casein in two gallons of hot water for two hours.
   2. Dissolve three pounds of trisodium phosphate in one gallon of water.
   3. Mix these two and allow the casein to dissolve and cool.
   4. Make a cream of one sack of hydrated lime and seven gallons of water.
   5. *Slowly* add 3 to 4, stirring vigorously.
   6. Just before using, dissolve three pints of formaldehyde in three gallons of water and add it *very slowly* to 5, stirring vigorously. Do not mix more than can be used in one day.

D. 1. Soak five pounds of casein in two gallons of hot water for two hours.
   2. Add three pints of household ammonia to one gallon of water.
   3. *When cold*, mix 1 and 2.
   4. Make a cream of one sack of hydrated lime and seven gallons of water.
   5. *Slowly* add 3 to 4, stirring vigorously.
   6. Just before using, dissolve five pints of formaldehyde in three gallons of water and add it *very slowly* to (5), stirring vigorously.
   7. Thin to a milk-like consistency.

E. 1. Dissolve three pounds of glue in two gallons of hot water and allow to *cool*.
   2. Make a cream of one sack of hydrated lime and seven gallons of water.
   3. Mix (1) and (2), stirring vigorously.
   4. Thin to a milk-like consistency.

F. 1. Make a cream of one sack of hydrated lime and eight gallons of water.
   2. Slowly add one quart of crude carbolic acid, stirring vigorously. The quantity of acid may be doubled, if desired.
   3. Thin to a milk-like consistency.

G. 1. Make a cream of one sack of hydrated lime and seven gallons of water.
   2. Dissolve six pounds of salt in three gallons of boiling water.
   3. Mix (1) and (2) when cold.
   4. Stir three pounds of Portland cement into (3).

USES FOR THE DIFFERENT FORMULAE

Formula A. and B. Unimportant outdoor work, sheds, fences and trees.
" C. and G. Higher grade of work on dairies, buildings and trees.
" D. Basements that tend to be damp.
" E. Dry basements.
" F. As a disinfectant wash but liable to rub.

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BULLETIN 330] [JUNE, 1927

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

The Farm Water Supply
and Sewage Disposal

FEATURING:

1. Pure water supply—where and how to get it, and how to keep it pure.
2. All about wells and pumps and their operation.
3. That water supply system of your home solved at last, whether hand, gas, or electric operated.
4. The hydraulic ram pumping spring water.
5. Equipment of your home with plumbing fixtures.
6. Serviceable water systems for the stable.
7. Sanitary sewage disposal systems for rural homes.
8. How to take samples of well water for analysis, and where to send them for examination.

WHY PURE WELL WATER PAYS.

The desirability and importance of an ample supply of pure water on every farm can hardly be over-emphasized. Perhaps more than any other food element, it determines the healthy and robust development of the body. Inversely, deadly disease germs finding access to poorly protected or unfortunately located wells may bring death, with little warning, into the family circle. Without great expense the water supply on the average farm may be so protected as to prevent contamination, and it surely seems the part of wisdom in every case to ensure an abundant supply of pure water for man and beast—and to have lavish use made of it.

OBSTACLES TO ITS FREEST USE.

But even though the water be pure there are obstacles in thousands of cases which prevent its convenient use. Where the household supply is drawn from a well or a stream at some distance from the dwelling the physical labour involved is great. It may be assumed that when no plumbing is installed, ten gallons per person per day for all purposes is necessary. With a family of four, some one—often the housewife—must carry 400 pounds of water a day, or over one ton a week. Considerable danger from exposure during inclement weather is also involved, especially when, in haste of the housework, womenfolk leave hot kitchens to carry in water without taking sufficient precaution against the cold.

In the stable much the same conditions exist. The task of pumping water by hand for a large number of live stock is slow and arduous—wasteful of time and trying to the temper. And in cold, stormy weather the stock, when driven to an outside tank or an ice-covered stream, will rarely drink sufficient for their best performance or development.

THE REMEDY.

The only way out of these difficulties is the installation of modern water supply systems both in the house and stables. The advantages of these systems certainly warrant the necessary expense. Thousands of stables have been equipped in latter years with modern water systems which supply the stock with an abundant supply under the most favourable conditions. It is unfortunate that far fewer houses than stables are thus equipped. Water systems in each case pay their way in dollars as well as in convenience, comfort and health.

This latter argument has been well developed by a practical farmer, who also has lived in a city, and whose experiences in this regard were published recently in an Ontario farm journal. He writes as follows:—

> "Our water system, more than any other improvement that we have made around the place, gives us unending satisfaction and has robbed the city home of what was once its leading point of superiority. Not only have we found it quite possible to have running water, hot and cold, in a farm home, but the installation is less expensive than it is in the city. Our city installation cost us $225, a large part of which was plumbers' bills. Our farm bathroom represents an outlay of not more then $150.
>
> "And what a comfort is a bathroom! I enjoy it to the full. I wouldn't be without it if the cost were twice as great. But the women folks are the chief beneficiaries. No more longing for the comforts of the old city home. They have them right on the farm. I don't anticipate that they will be instrumental in furthering rural depopulation, for, if all reports be true, rural women who live without city conveniences have a habit of sowing seeds of discontent and taking the whole family off to town."

NOTE BY THE AUTHOR.—Our recent work on this matter of cost of a plumbing system for a rural home proves that a complete system of plumbing costs more than $150; it is about $275 when good quality fixtures are used and a trained mechanic installs it. If cheaper material be used and home labour be engaged, the cost of course could be considerably less than this figure.

However, the question of cost which this farmer mentions is important. There are few indeed but will admit that a complete water system and plumbing for the farm is highly desirable; but many are deterred because of the expense involved. Many improvements may be made, however, such as safeguarding the well from pollution, installing an hydraulic ram, septic tank, gravity system, etc., which are not very expensive. And when the farmer is able to do a good deal of the work himself the cost is reduced to a point where thousands can afford the installations. Many different systems and devices, or modifications of these, may also be used according to local requirements and the peculiar circumstances of each case. With a practical working knowledge of the principles of farm water supply, water systems, equipment and sewage disposal, few indeed who have impure well water and are without household and stable water conveniences, but can make improvements of a most beneficial nature and at a cost which they can afford to pay.

Washing Dishes. Hot water on tap at sink.

Winter scene without water system.

PURPOSE OF THIS BULLETIN—SERVICE.

To give such information is the purpose of this bulletin now presented to the farm public of Ontario. Practical information, as complete as possible and so arranged as to enable each reader to find quickly the particular problem he is most interested in, is given regarding every phase of the water question. To further assist those who may wish to make improvements or installations the authors of this bulletin will gladly give personal attention whenever possible to any question or problem which may be sent to them. All are invited to make use of the appendixes at the back of the bulletin, to procure blanks as directed, to fill them out carefully and to forward them to Department concerned.

THE FARM WATER SUPPLY

THE MANNER OF OCCURRENCE AND THE QUANTITY.

In gaining an appreciation of water supply problems, and a knowledge of how to solve them, it is desirable first to make a brief study of the occurrence of underground water. The earth is composed of a number of layers or strata. Some, like sands and gravels, are loose, open, porous, and water passes through them readily; others, like heavy clay, hardpan and rock, are so compact and the pores therefore so small that water passes through them very slowly if at all. These pervious or porous layers, and impervious or non-porous ones are very important from the standpoint of water supply. Frequently they are distributed somewhat as follows: First, a pervious layer of soil on the surface, thin in some places and thick in others. Secondly, an impervious layer of clay, hardpan or shale rock. Thirdly, a pervious layer of sand, gravel or shale, and fourthly, an impervious one of solid rock. But the number may be even greater than this, or the solid rock may extend right to the surface. Fig. 1 shows a possible distribution.

When rain falls upon the land shown in Fig. 1, part of it soaks into the porous layers, as at A or C, and part may run off over the surface. Also that which falls on the impervious layer as at B must find its way over the surface to the porous layers and into them or over their surface to a stream or pond. When the porous layers at the surface are saturated in part, the ground water-level would be somewhat as shown by the dotted lines. At A, A′, and C, dug wells sunk in the porous layers would give a supply of water, and the level in the wells would be the same as the ground water level. At B the impervious layer comes to the surface and a well sunk in it would give no water until the porous layer beneath it was struck. Then the water would rise to the same ground water level as in the well at C. A well drilled at A deep enough to strike the second porous layer would produce a flowing or artesian well. At D, where the surface layer becomes quite thin, the water would in all probability break out, forming a spring, or saturate the soil all round, causing a "springy spot." And indeed it would be possible for the water from the second porous layer to find a crevice or channel through the upper layers and produce a spring as at E.

The origin of water in the earth is not always so evident as in Fig. 1. Particularly in arid and semi-arid regions is this the case, e.g., in Saskatchewan and Alberta and in parts of Australia and India. In many such localities the precipitation is not sufficient to saturate the surface layer and produce a ground water level in it. And drilling even to a depth of hundreds of feet may fail to

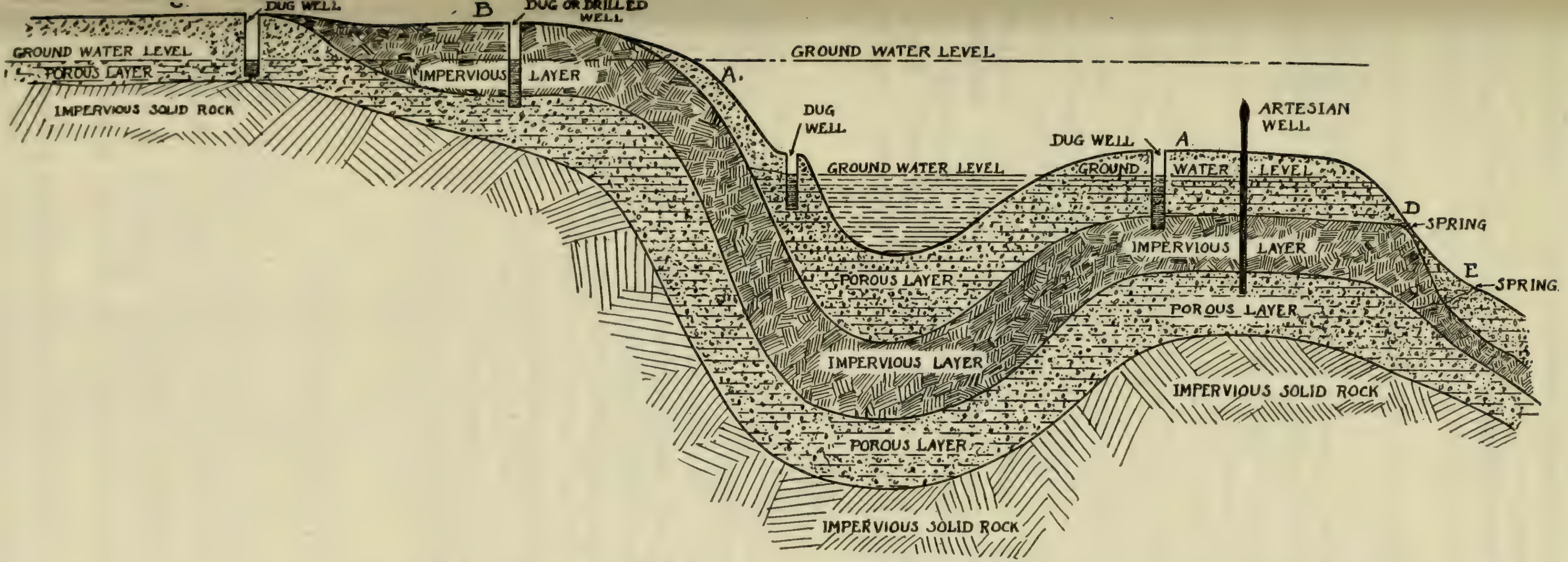
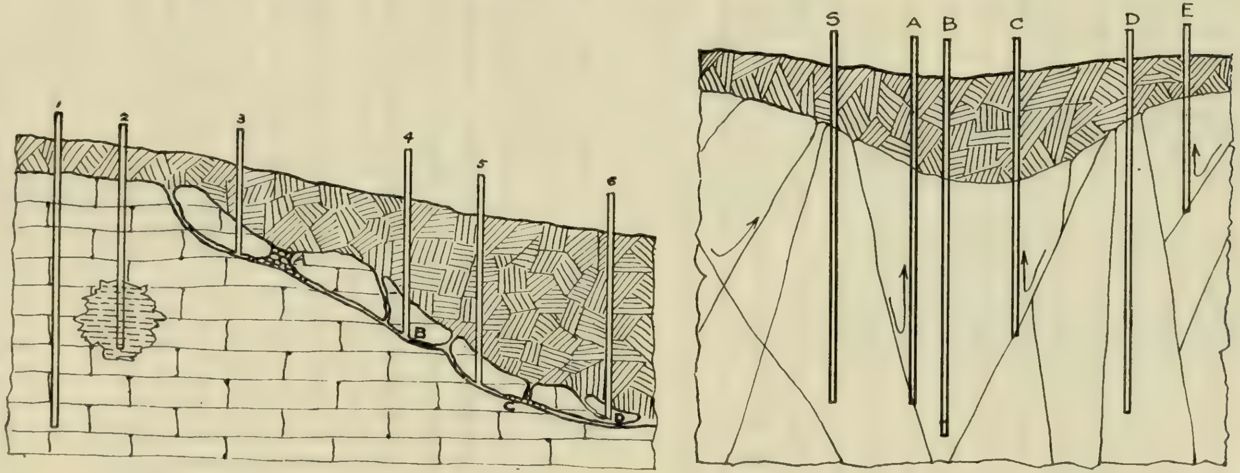


Fig. 1.—Showing soil layers, ground water levels, wells and springs.



(a)

(b)

Fig. 2.—Manner of occurrence of water supply.

locate a water-bearing stratum farther down, and yet occasionally shallow wells sunk in these areas tap veins or underground streams, rivers or lakes, whose sources we do not know, nor their outlets.

In limestone formations the water occurs in crevices between the layers of rock and in underground holes or caverns or sometimes in channels, as illustrated in Fig. (2) (*a*).

In the granite types of rock, the water, if any, occurs in the cracks or cleavages, as shown in Fig. 2 (*b*).

The quantity of underground water depends primarily upon the rainfall, and secondly upon the capacity of the soil and rock to hold water. Clays and loams are good water-bearers but they give it up slowly.

Sandstone on the whole is the best water-bearer of the solid rocks, and the quality is second to none, except that from sand and gravel formations. Limestone rock is a pretty good water-bearer, a very good supply being obtained if the well is sunk into open channels, or caverns in the rock. Granites and rocks of this type are poor water-bearers except for wells drilled into intersections of many joints in the bed of the rock. Sand and gravel beds usually give good supplies of high quality water, and a driller is lucky if he strikes a good bed of this material deep below the surface. Well drillers usually figure that they can get plenty of water in sandstone or limestone formations at reasonably shallow depths, 100 feet more or less, and sometimes even in solid rock like granite, if they go deep enough to intercept sufficient joints as feeders of the well. They are not so lucky in slate formations as in granite rocks, as the former are the poorest water-bearers.

FINDING WATER.

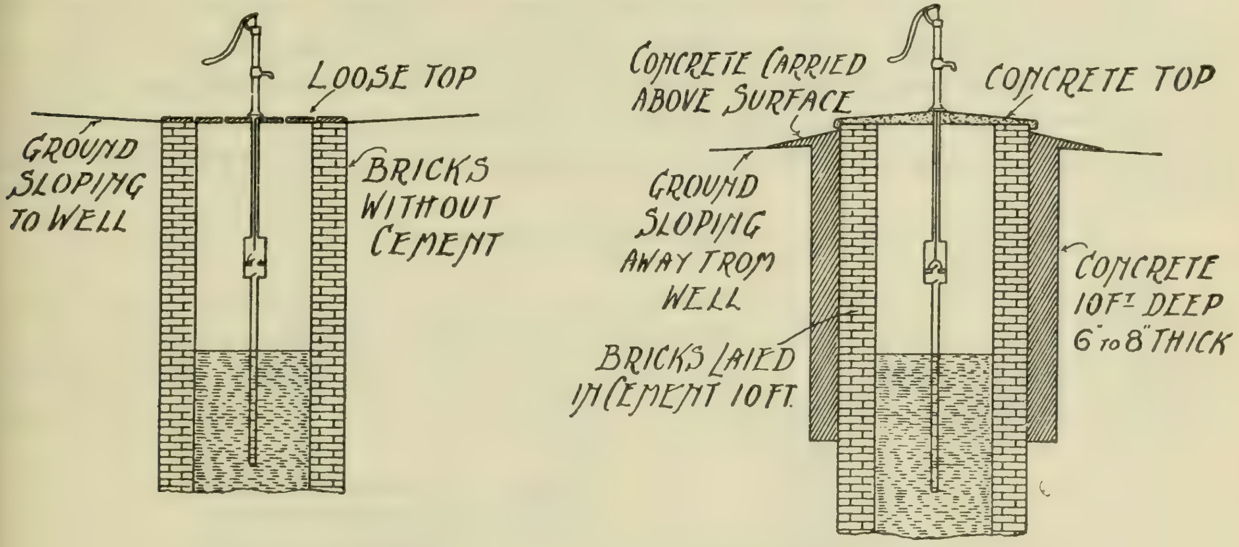
This has always been a matter of great concern among the farmers in many localities, and unfortunately for them there is no reliable method as yet for finding water. So-called "water diviners" may help in some cases, but they fail as often as they succeed, or oftener, and therefore are not reliable indicators. The electrical water-finder likewise has failed. In view of these facts we think that the following statement taken from Fuller's text on "Domestic Water Supplies" is not far astray, "so far the only scientific basis for locating water is a knowledge of the laws of occurrence and movements of the ground water, for on these factors depend the quantity, the quality and safety of the supply." This means that the best clue to the occurrence or not of underground water is a knowledge of the soil and rock beneath the locality in question. The character and depth of the existing wells in the locality may also be a useful guide, or the logs of such wells if available.

HOW TO KEEP THE WATER SUPPLY PURE.

The Provincial Board of Health, in its laboratories at Toronto, and the Ontario Agricultural College, Guelph, have tested thousands of samples of water from wells in rural districts yearly, and the results show that there is a great deal of contamination of well water—about eighty-five per cent. of those tested were contaminated. For this reason we wish to call special attention here to the location, construction and care of wells in order that the character of the water may be improved.

As to the matter of location, wells should be located on higher ground than any possible source of contamination such as a barnyard, or cesspool, and always at a safe distance, 100 feet in ordinary soils and probably twice that distance in loose, porous soils like coarse sands and gravels.

The construction of shallow or dug wells should be carried out as indicated in Figs. 3 (*b*) and 4, in order to keep out surface and underground contamination. The same materials or manner of construction need not be employed in all cases, but the principles indicated should be applied strictly in every instance.


LOOSE TOP
GROUND SLOPING TO WELL
BRICKS WITHOUT CEMENT
CONCRETE CARRIED ABOVE SURFACE
CONCRETE TOP
GROUND SLOPING AWAY FROM WELL
CONCRETE 10 FT. DEEP 6" TO 8" THICK
BRICKS LAIED IN CEMENT 10 FT.

(a) Poor dug well. (b) Good dug well

Fig. 3.—Shallow dug well.

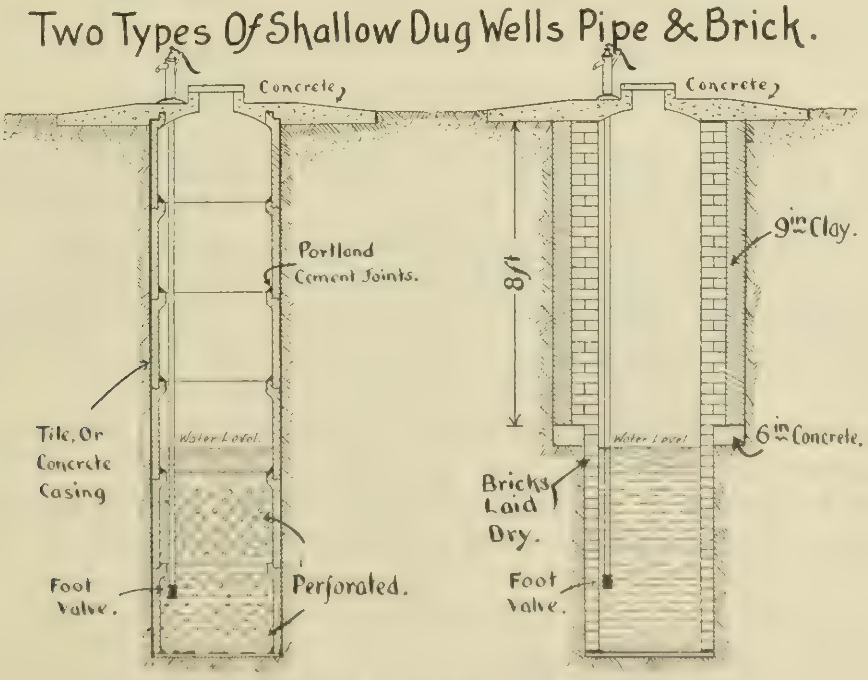
DIFFERENT TYPES OF WELLS

Our Main Source of Water Supply.

There are three or four standard types of wells—the *dug*, the *drilled*, the *driven*, and the *bored*.

The Dug Well.

When the ground water occurs in soils or loose materials that can be dug or picked, and within a reasonable depth, the dug or shallow well is the common type. Since the ground water seeps through soils very slowly, particularly the



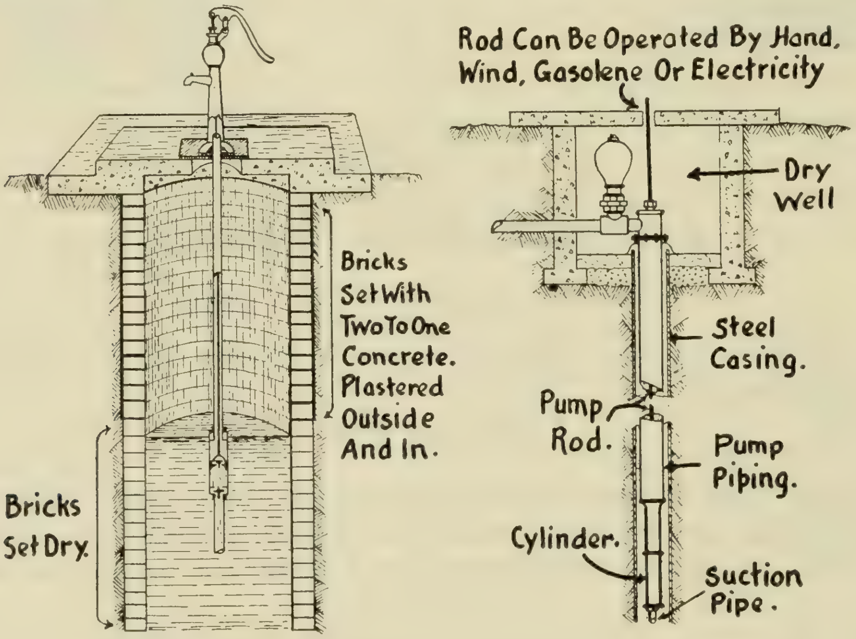
(a) Fig. 4. (b)

clays, the dug wells have to be made large in circumference in order to provide sufficient seepage area to let enough water into the well. As a rule, they vary in depth from 10 to 100 feet, but they may be deeper. Figs. 3 and 4 illustrate typical dug wells and how they should be cribbed and covered.

Many shallow wells go dry in time owing to changed conditions of the soil and become dry wells. In some cases it pays to dig them deeper or else bore or drive in the bottom of them until water is struck. If bored, it would be necessary to case the hole, and the casing should be brought up to the surface in order to keep out contamination that might enter the dry well. This type is illustrated in Fig. 5 (*b*).

The Drilled Well.

This is the deep type sunk through soil or rock formation by a special tool or machine operated by the professional well driller. Water may be struck at various depths, frequently at 200 or 300 feet, but sometimes much greater depths are required. Since the water comes from such low levels it is almost certain to be pure and wholesome. The quantity is variable, depending on the nature of the water-bearing strata that are tapped. The size of the hole varies from three to six inches, and it passes down through the surface layer of soil and through the non-porous layer of clay or rock below it into a second water-bearing layer beneath. The bore is protected with a water-tight wrought-iron casing, which when the rock is penetrated is driven firmly into the rock to exclude surface water, but no casing is used through the rock.


Bricks Set With Two To One Concrete. Plastered Outside And In.
Bricks Set Dry.
Rod Can Be Operated By Hand, Wind, Gasolene Or Electricity
Dry Well
Steel Casing.
Pump Rod.
Pump Piping.
Cylinder.
Suction Pipe.

(a) (b)

Fig. 5.—Two types of deep wells, brick and bored.

The contract for boring a well is usually made on the basis of so much per foot, which price includes casing and testing for water, etc.

The drilled well is one of our best and most reliable wells and is very common in certain areas. Various drilled wells are illustrated in Figs. 5 (*b*), 14 and 34.

Driven Wells.

Where the soils are such that a pipe can be driven down into a porous water-bearing stratum such as sand or gravel, then driven wells may be constructed much more easily and cheaply than dug wells. The method of procedure is as follows:

1. A well point (such as shown in Fig. 6) is procured.
2. The point is screwed on to a pipe of the proper size, and a drive cap on the top of the pipe. Usually 1¼ or 1½-inch pipe is used for ordinary farm wells.
3. The point and pipe are driven into the ground by sledge, maul, or drop weight, until the end is just above ground. Care should be taken to have the pipe perpendicular. Sometimes when a hard layer of soil is struck the pipe is withdrawn and a hole bored through the hard layer by a special auger, and then the driving continued.
4. Another length of pipe is then put on, and the operation repeated.

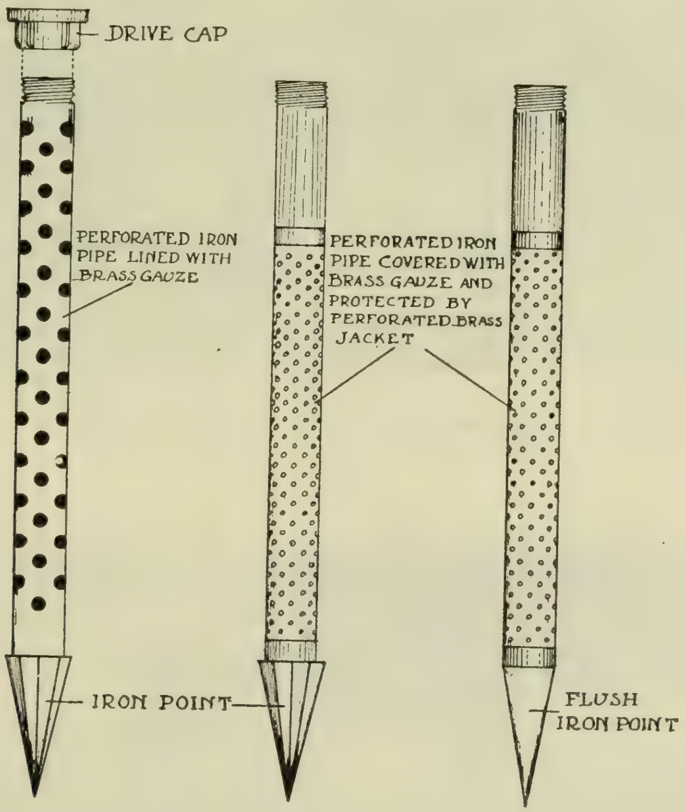

DRIVE CAP
PERFORATED IRON PIPE LINED WITH BRASS GAUZE
PERFORATED IRON PIPE COVERED WITH BRASS GAUZE AND PROTECTED BY PERFORATED BRASS JACKET
IRON POINT
FLUSH IRON POINT

Fig. 6.—Types of well points.

5. Tests for water are made from time to time. This is done by letting down a plumb bob inside the pipe.
6. For a satisfactory supply of water the point should be driven a considerable distance into the porous layer, but care must be taken not to drive through it into the non-porous layer beneath. To ascertain whether the supply is adequate a pump is attached to the top of the pipe and pumping is continued for several hours. If the supply fails under this test, the point should be driven deeper in the porous layer. Where the water-level is more than twenty-five feet down, the hole would have to be large enough to admit the pump cylinder to the required depth.
7. The pump is then fixed permanently in place. There are three methods of doing this: If there is no danger of freezing, the pump, including cylinder and sucker, may be placed entirely above ground, the cylinder being screwed directly to the pipe when the drive cap is removed. Or the pump may be placed in kitchen or stable, as desired. If there is danger of freezing, a shallow dry well as seen in Fig. 5 (*b*), may be dug as far down as the first joint in the pipe, when the top length is removed and the pump placed in its stead, the cylinder

being down near the bottom. This dry well for the pump should be cribbed and a tight cover provided, but the cribbing need not be backed with cement or puddled clay. The third method is to put the cylinder in the drive pipe.

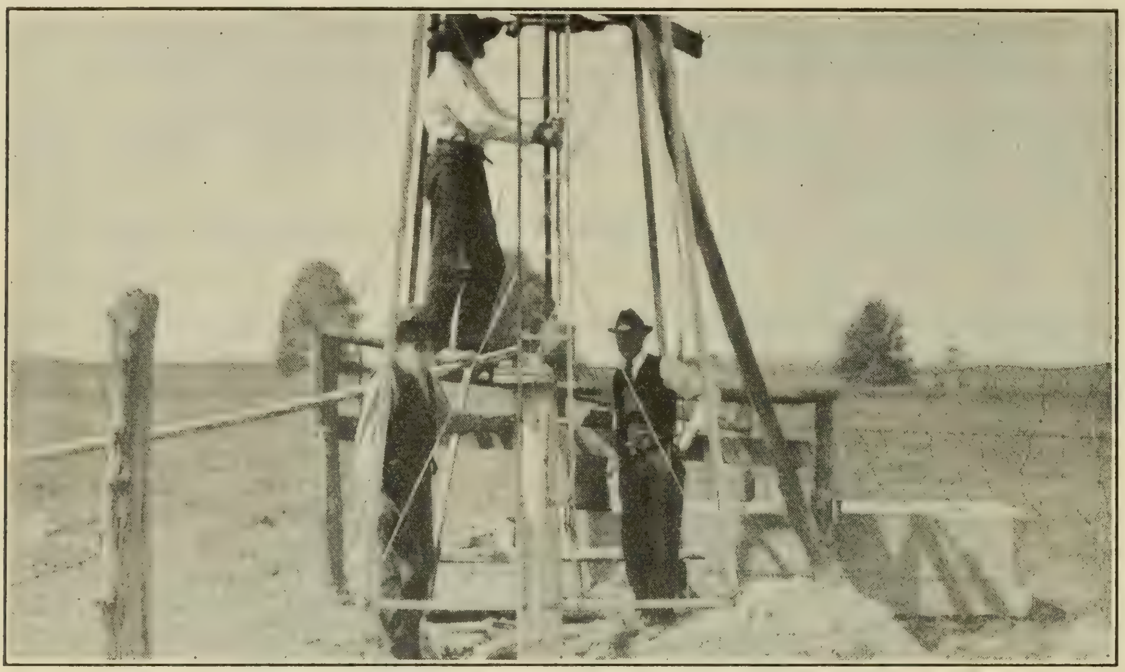


Fig. 7.—(*a*) Sinking the open 10-inch drive pipe.

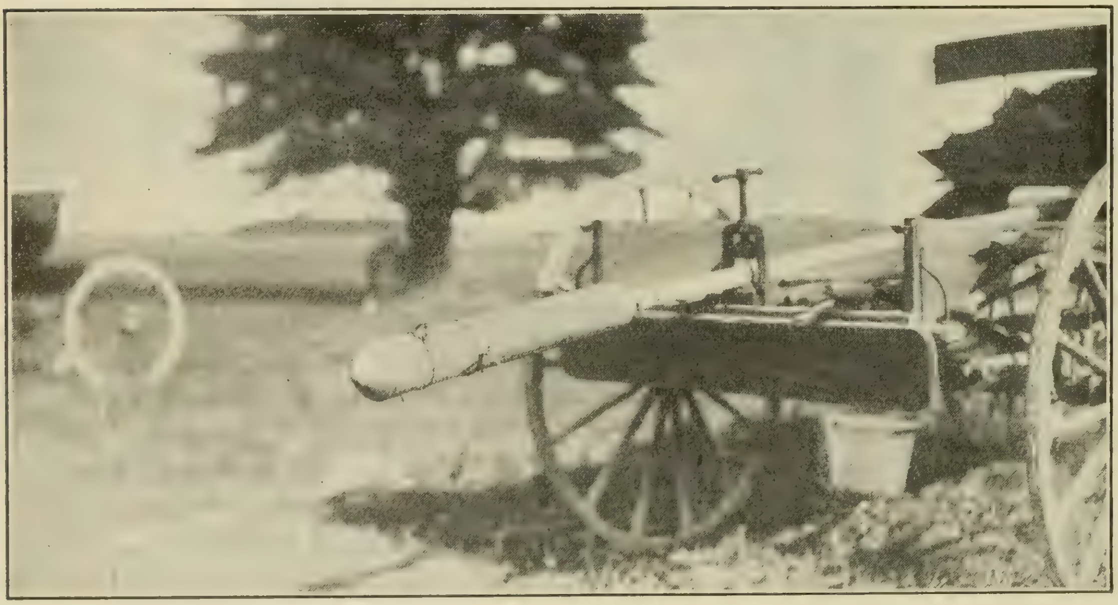


Fig. 7.—(*b*) Sand filter, to be placed in open drive pipe.

The driven well is sometimes constructed without a drive-point. In this case the open pipe is driven down until driving becomes difficult, when the cap is removed, water poured into the pipe and the soil after being loosened by a drill is removed by means of a sand pump. When the water-bearing layer is struck the pipe is driven a short distance into it and then the hole sunk somewhat farther by means of the drill and sand pump.

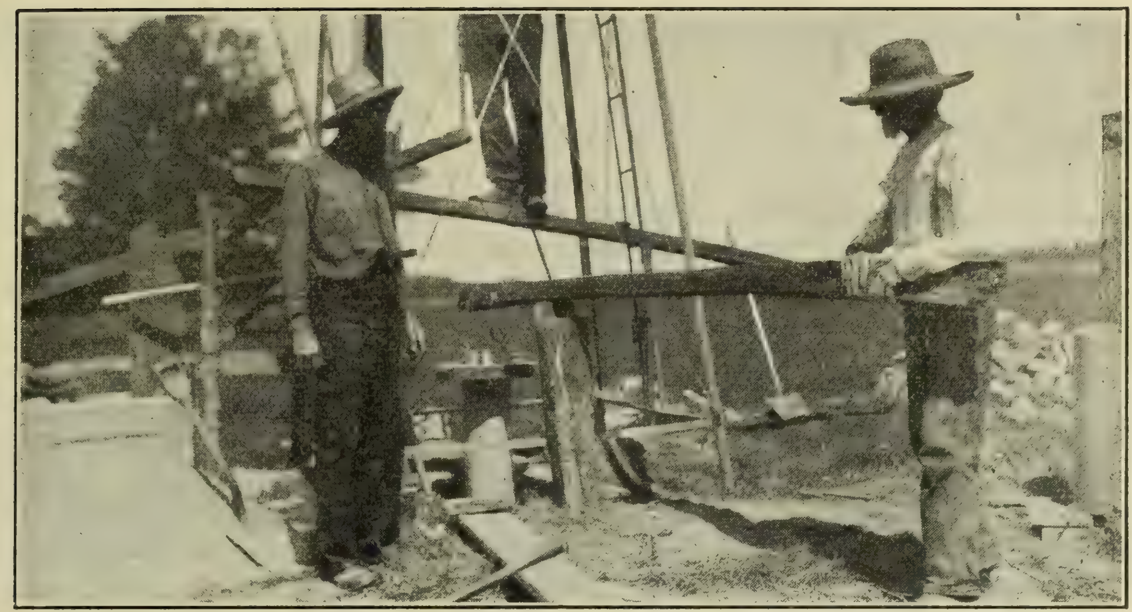


Fig. 7.—(*c*) Withdrawing open drive pipe.

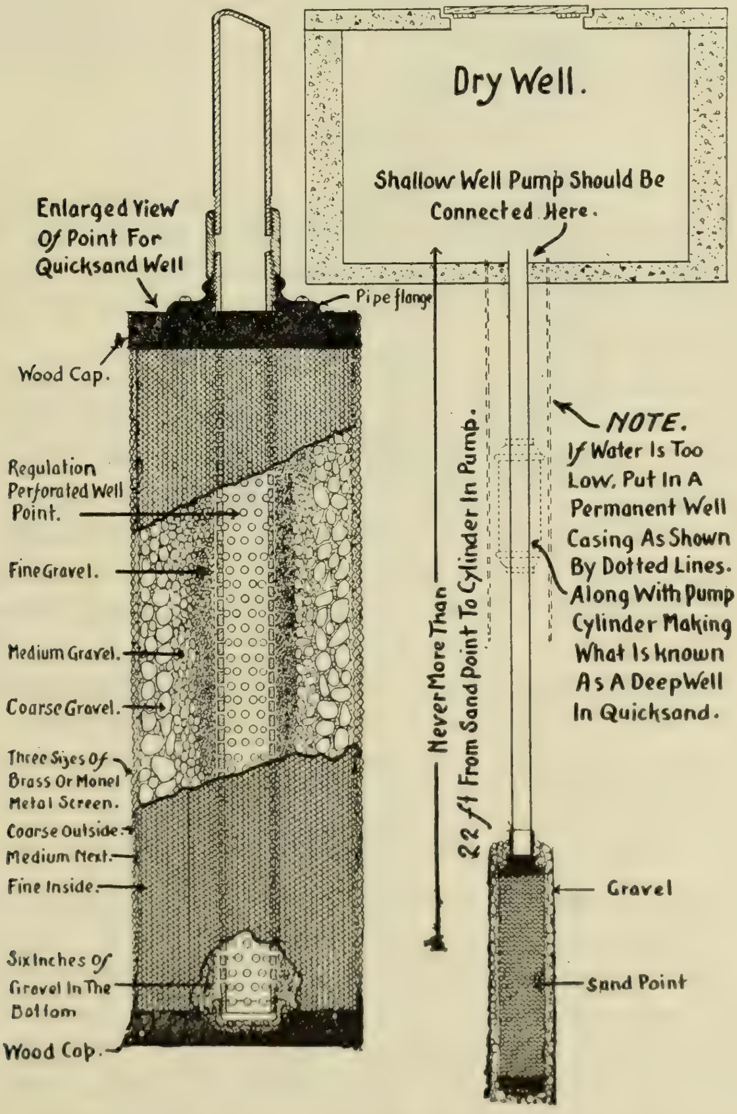

Dry Well.
Shallow Well Pump Should Be Connected Here.
Enlarged View Of Point For Quicksand Well
Pipe flange
Wood Cap.
Regulation Perforated Well Point.
Fine Gravel.
Medium Gravel.
Coarse Gravel.
Three Sizes Of Brass Or Monel Metal Screen.
Coarse Outside.
Medium Next.
Fine Inside.
Six Inches Of Gravel In The Bottom
Wood Cap.
Never More Than 22 ft From Sand Point To Cylinder In Pump.
NOTE.
If Water Is Too Low, Put In A Permanent Well Casing As Shown By Dotted Lines. Along With Pump Cylinder Making What Is known As A DeepWell In Quicksand.
Gravel
Sand Point

Fig. 7.—(d)—Quicksand wells and points described.

The water from a driven well is turbid at first, but after a time becomes clear, as the finer particles of soil are gradually removed from the areas about the point.

The advantages of the driven well are:

1. Its cheapness.
2. Its sanitary qualities. Surface water cannot reach the point without filtering through twenty to twenty-five feet of soil.

Driven Well in Quicksand.

Sometimes in driven wells the sand is so fine that it blocks up the ordinary drive point. In overcoming this considerable success has been attained by using a special filter attached to the suction pipe as shown in Fig. 7 (*b*) and (*d*). The filter is made similarly to the drive point, only being larger, about six to eight inches in diameter and three feet long. In this case an open drive pipe or casing is used, and it must be large enough to admit the filter, and a jacket of gravel, usually about ten inches in diameter. A good pipe for this purpose may be made of very heavy galvanized iron sheeting, the sections being detachable and with a locking device. When the pipe has been driven down into the water-bearing area all the earth is removed from it, then a foot or so of coarse gravel placed in the bottom, the filter screwed to the suction pipe and set on the gravel, and enough fine gravel put in to fill the space between the filter and the drive-pipe. The latter is then withdrawn, as shown in Fig. 7 (*c*), and the pump attached to the top of the suction pipe.

The Bored Well.

In instances where the soil is quite loose and free from stones and boulders, and where a good water-bearing layer of material lies within twenty or thirty feet of the surface, at any rate not exceeding fifty feet, the well or hole may be sunk by an auger, if hole is two or three inches in diameter, or by a special soil auger or well borer for larger holes.

In the small-sized ones the hole is not big enough to admit a cylinder, and consequently the water must lie within the suction distance, say twenty to twenty-five feet from the surface where the cylinder must of necessity be located.

The smaller wells are cased with iron pipe 1½ or 2 inches in diameter and the larger ones with wooden casings or cement tile. The casings should be forced to a depth a little lower than the water level, and if soil at the bottom of the hole is not loose or gravelly the lower portion of the casing should be perforated to facilitate ingress of water. If quicksand or very fine material is encountered, a drive point or screened pipe may have to be attached to the lower end of the suction pipe. If coarse gravel be dropped around this filter or screen it will often be beneficial in preventing clogging of the pipe by entrance of sand.

Artesian Wells.

The classification of wells just described is based upon the different methods of sinking wells. The artesian type is a particular one, being named after a small town called Artois, in France, where a noted well of this kind once existed. Its occurrence and manner of flow is its peculiar feature and it is well illustrated in Fig. 1, page 00. It will be noted in this figure that the head of water for the porous layer into which the artesian well is sunk is very much higher (see C on the left) than level of water in same porous layer on the right. The greater this difference the stronger the flow will be. These wells may overflow or not, depending upon their volume and strength.

The pump may be installed on such a well in the same manner as on a drilled one, except where flow is very strong, when all that is needed is a delivery pipe to convey water to level or point where water is required.

SPRINGS.

Next to wells as a source of water supply are the springs. In certain areas the geological formation is very favourable to the occurrence of springs, in others it is quite the reverse. Springs vary in respect to mode of origin, manner of emergence, in size, depth of origin, and the nature of the water. Springs, as a rule, produce the purest and most wholesome water we have, and a large share of them yield a lot of water the year round, and never fail even in the severest droughts.

The service rendered by springs depends upon their capacities, and their elevation and location in respect to the farm buildings. If a good spring is located reasonably close to the home and on higher ground, the water may be supplied by gravity to the buildings, as shown in Fig. 40, or if on lower ground it may be pumped up by the hydraulic ram, as described and illustrated on pages 27 to 35, or if the spring be close to the buildings the water may bec arried or pumped into the buildings. Again, if springs are located in the pasture land they afford excellent watering-places for the stock during the pasturage season or maybe even in the winter time if they are not too far away.

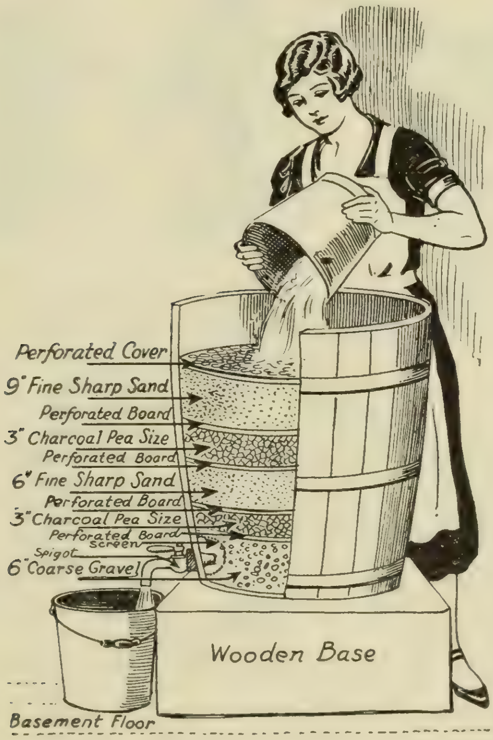
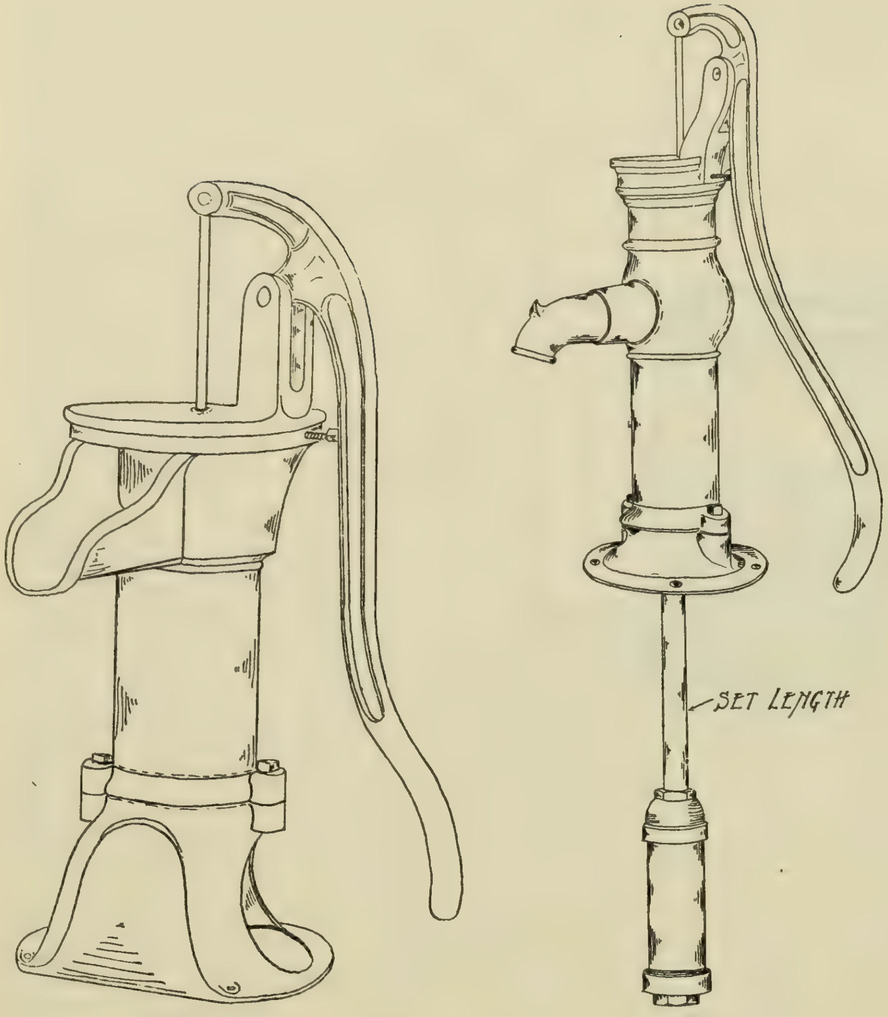


Fig. 8.—Suggestion for simple filter to make soft or cistern water drinkable.

If springs are to be used as regular supplies of water, it is worthwhile to improve and protect them by cleaning out and probably deepening the basin, cribbing up its sides and putting on a lid or top to exclude foreign matter, as illustrated in Figs. 26 and 40.



(a) (b)

Fig. 9.—(a) Cistern pump with cylinder in barrel.
(b) Set length cistern pump.

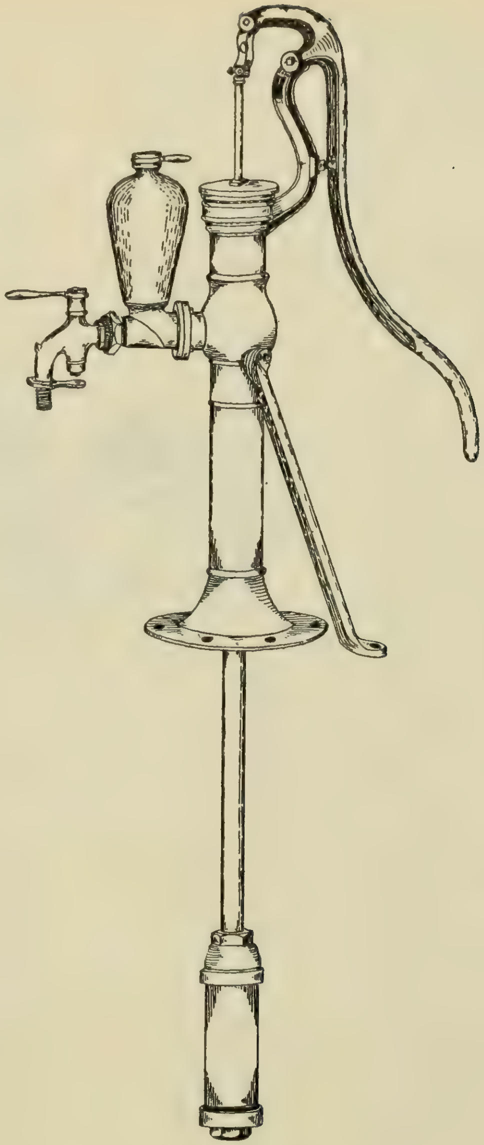


Fig. 10.
Force pump, with air-dome on spout.

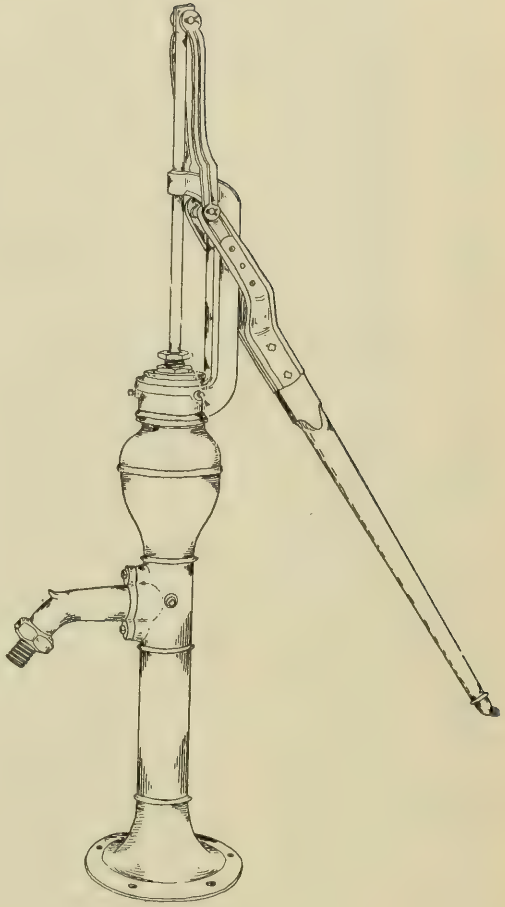


Fig. 11.
Force pump, with air-dome in barrel.

FARM PUMPS.

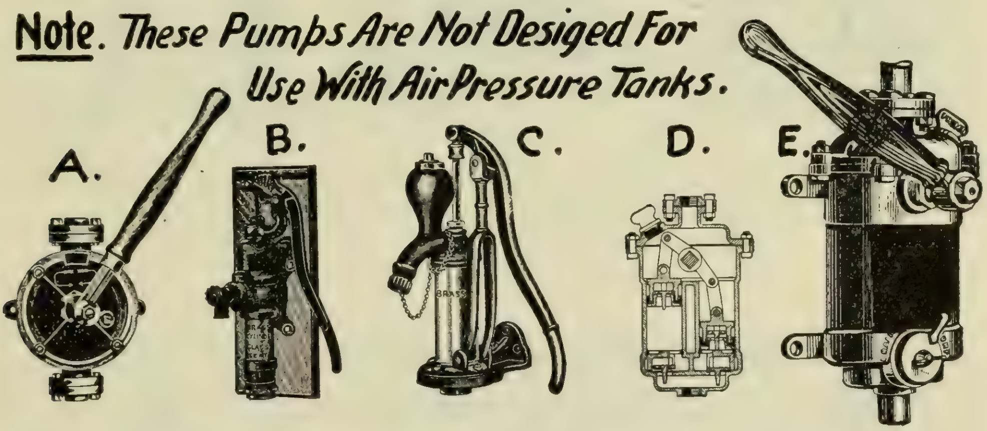
Classification of Pumps.

1. *House lift and force pumps.* Figs. 9 (*a* and *b*) and 12.

Pitcher spout and cistern lift pumps for shallow wells and cisterns. House force pumps for hand use in domestic water supply. Either with base or bracket support. This class includes the two newer types, namely, double action oscillating and tandem. In the ordinary house pumps the cylinder may be in the standard or lowered as a separate unit.

2. *Set length lift and force pumps.* Figs. 10 and 11.

The cylinder is below the platform. Non-freezing outdoor pumps for shallow wells and cisterns for both hand and windmill use. The set length or pipe between head and cylinder limited to three or four feet or thereabouts.



Note. These Pumps Are Not Desiged For Use With AirPressure Tanks.

Fig. 12—Four types of modern hand force and lift pumps.
A is a semi-rotary pump. B is a cog-geared wall pump. C is fitted with bracket at base.
D is a section view of double internal cylinder pump marked E.
All are very easy to operate.

3. *Well and windmill pump standards.* Figs. 13 (*b*, *d* and *g*).

Heavier pumps than the preceding, either lift or force and for either shallow or deep wells, the cylinder or working barrel being separate and usually submerged. The ordinary windmill pump is typical of this class. May be operated by hand, windmill or by gasoline engine.

4. *Deep well working heads.* Figs. 13 (*a* and *b*) and 14 (*b*).

These are strongly built. Newer types have automatic oiling, have brass, artesian well and other special types of cylinders. Operated by electric motor, gasoline engine or windmill. Cylinder is submerged. Pumps directly over the well.

5. *Horizontal, single and double acting, the latter being power driven.*

Many uses, such as contractors' use, water tank service in factories and mills. Pneumatic tank service for large estates, bowling green water service. Figs. 18 and 20.

6. *Hydro-pneumatic water systems.*

These may be shallow or deep well types. All are supplied with air valve, operated by hand, electric motor, windmill or gasoline engine. These types are used for pumping water into compression tanks for supplying private homes, large estates and institutions with water service. Fig. 39.

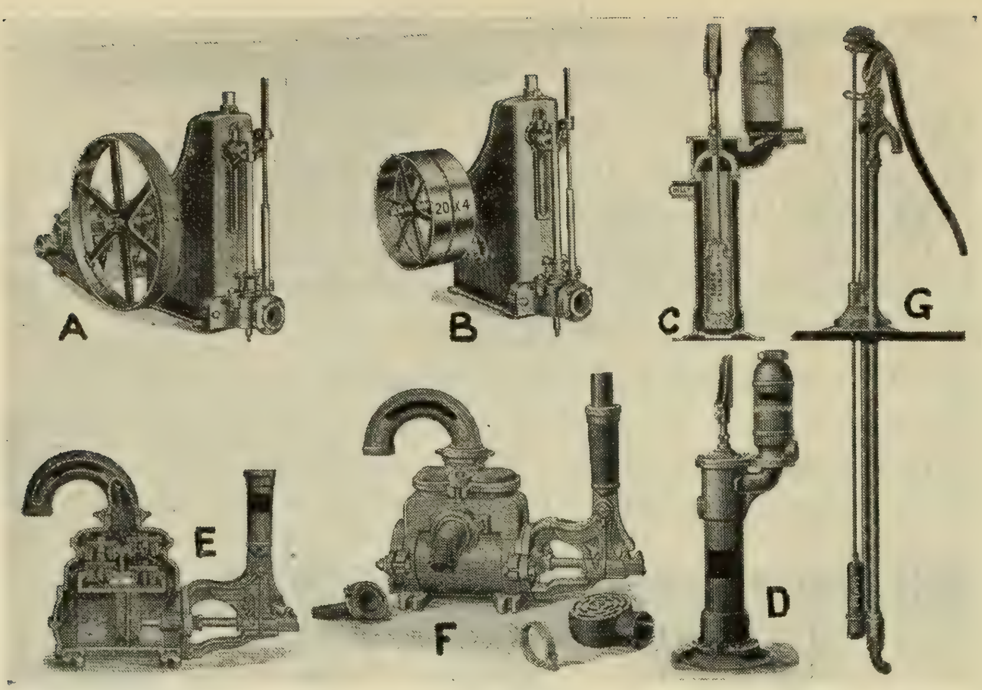


Fig. 13.—Various types of shallow, deep well heads and pumps. Hand, electric, gasoline and wind engine driven.

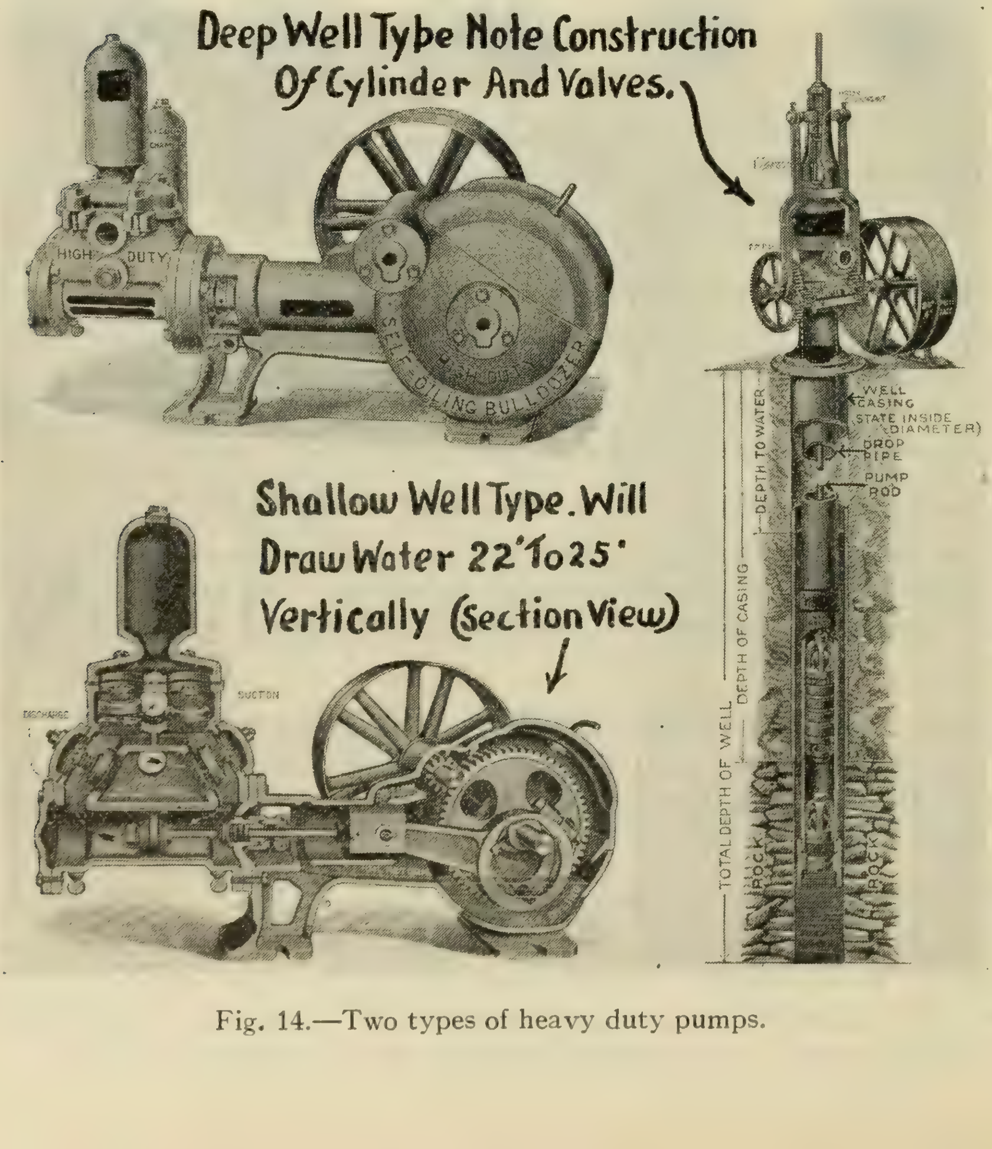

Deep Well Type Note Construction Of Cylinder And Valves.
HIGH DUTY
SELF-OILING BULLDOZER
WELL CASING (STATE INSIDE DIAMETER)
DROP PIPE
PUMP ROD
DEPTH TO WATER
DEPTH OF CASING
TOTAL DEPTH OF WELL
ROCK
ROCK
Shallow Well Type. Will Draw Water 22' To 25' Vertically (Section View)
DISCHARGE
SUCTION

Fig. 14.—Two types of heavy duty pumps.

PRINCIPLE OF PUMPING WATER.

In this connection the reader is referred to Figs. 15 and 16 as aids to fully understanding just how the ordinary pump is able to lift and force water from one level to another.

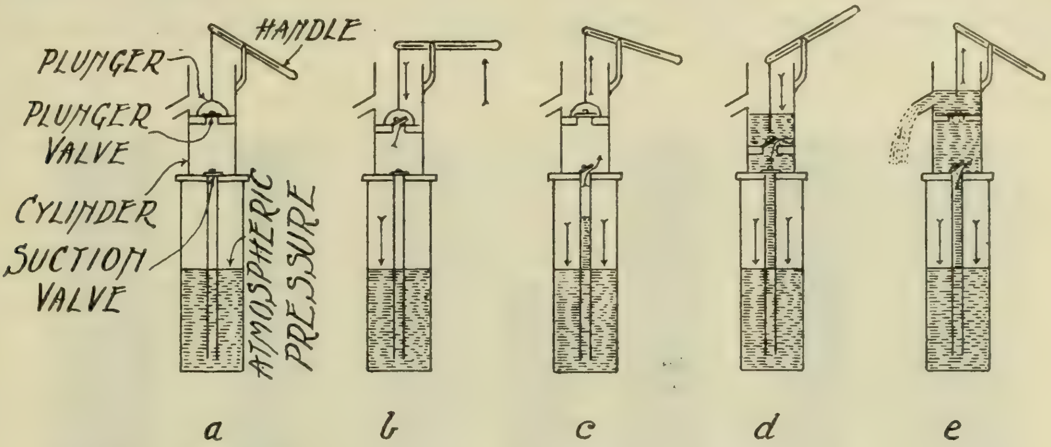


Fig. 15.—Stages in the action of the suction pump.
(a) The pump before use, both valves closed.
(b) First up-stroke—air in cylinder being forced out through valve in plunger.
(c) First up-stroke—air pressure in cylinder reduced. Atmospheric pressure on water in well drives water part way up the suction pipe.
(d) The water has reached cylinder, plunger moving down.
(e) Up-stroke—water begins to flow from spout.

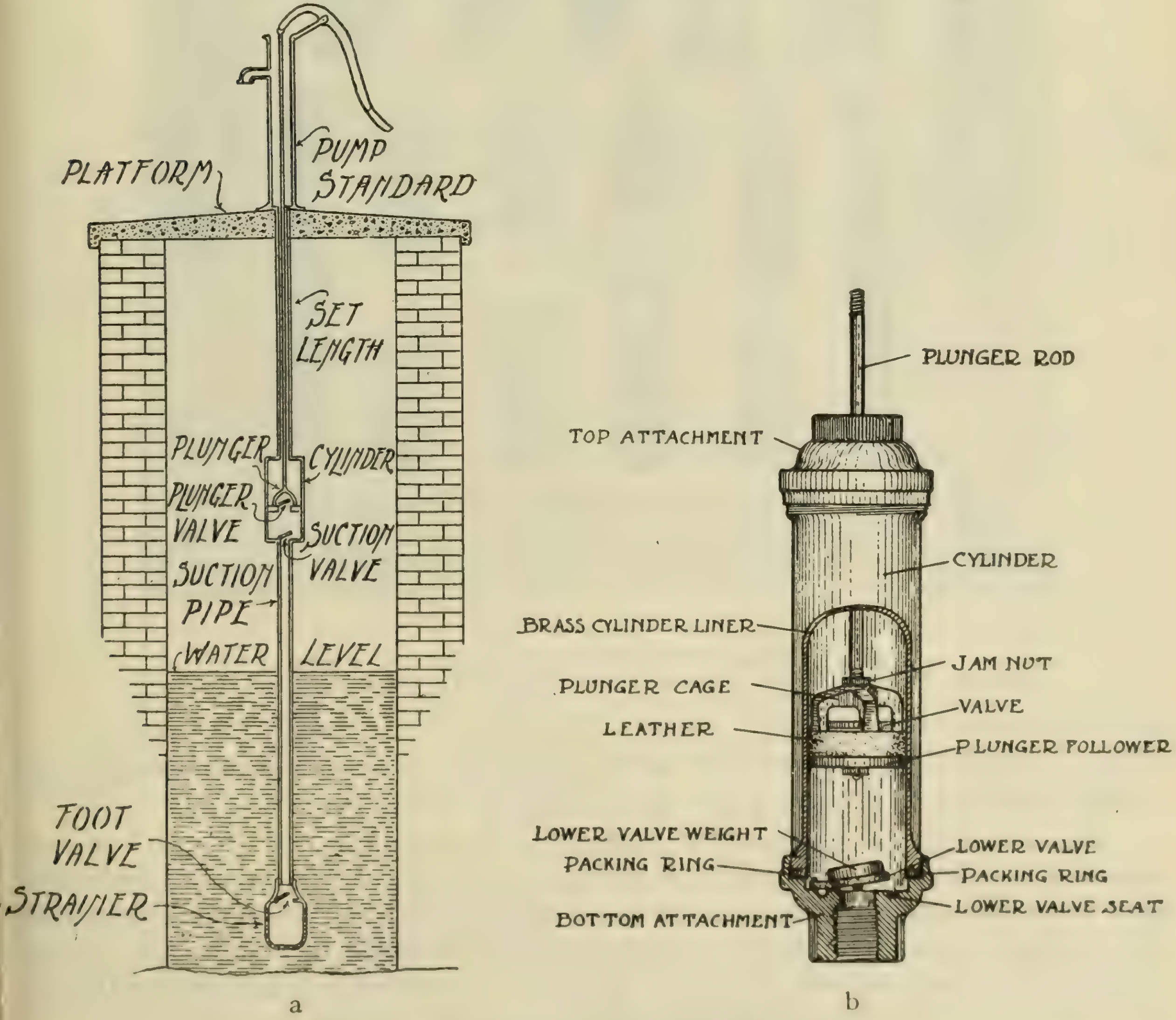


Fig. 16.—(a) Suction pump, showing parts.
(b) Cylinder and sucker, showing parts.

In the first place the atmosphere at the sea-level has weight or pressure enough to sustain a column of mercury thirty inches long or its equivalent a column of water thirty-four feet long, water being 13.6 times lighter than mercury. This means that if all the air in the cylinder shown in Fig. 16 were placed thirty-four feet above the water level, and all the air removed from it, the atmospheric pressure on the water in the well would raise the water into the cylinder and fill it. After this had occurred the function of the plunger or bucket would be to lift the water to the surface and deliver it.

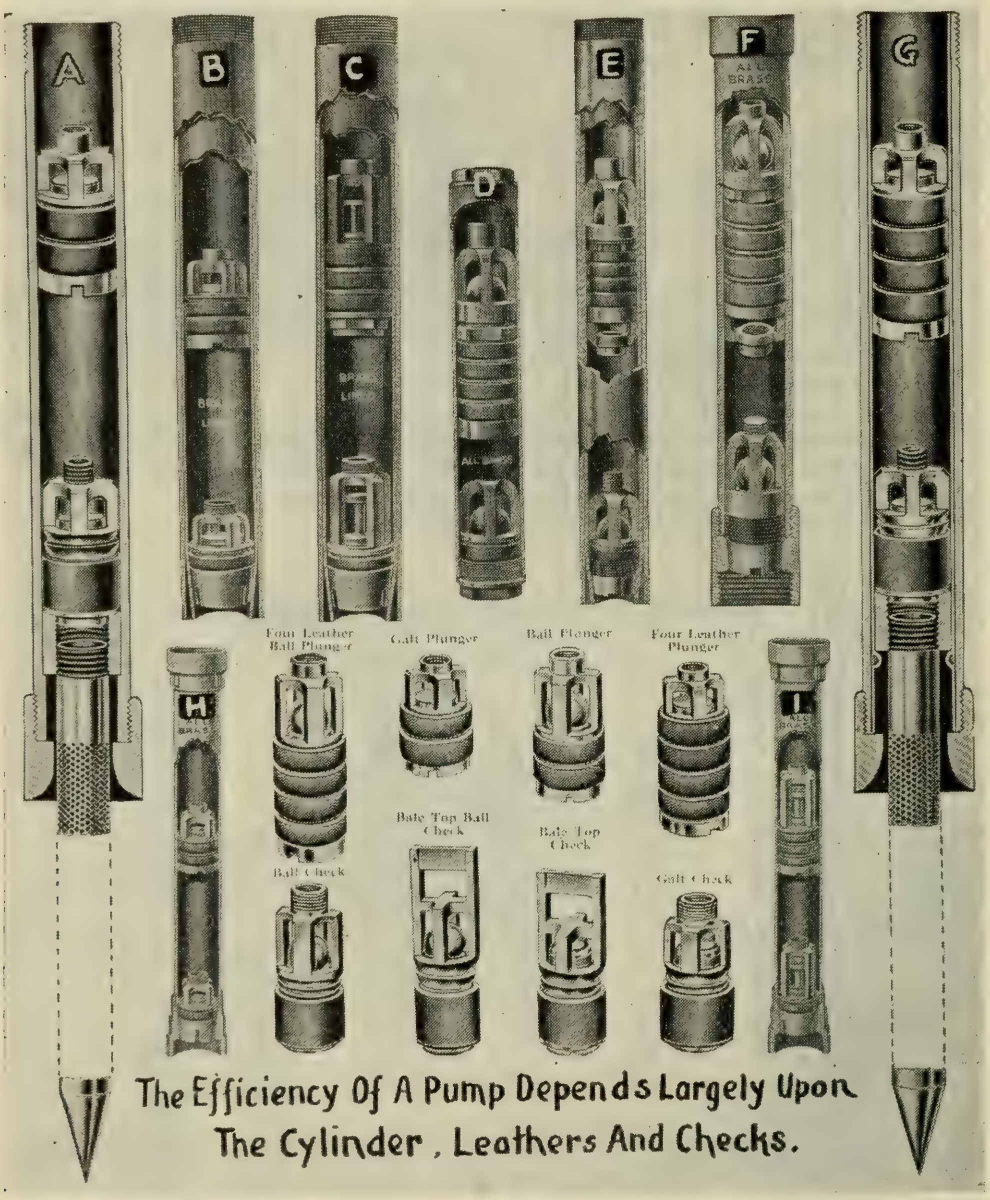


Fig. 17.—Deep well cylinders, plungers and checks.

The principle of pumping, therefore, is an inequality of pressure in the pump cylinder and on the water surface in the well or other source of supply. Since the atmospheric varies over the earth's surface being less than thirty-four feet at most places and chiefly because it is not possible to maintain a perfect vacuum in a pump cylinder, it is not feasible to use a suction distance of thirty-four feet, but only about twenty-two feet.

PUMP CYLINDERS.

The pump cylinder is the cylindrical chamber in which the plunger or bucket operates. They are constructed of metal, the best ones, and particularly those used in deep wells, are made of seamless drawn brass tubing or else of iron lined with brass or some alloy. The shallow well type of cylinder is illustrated in Fig. 16 (b) and the deep well ones in Fig. 17. The chief difference between the construction of the two types is the manner of attaching the caps, the former having outside, while the latter have inside caps. For this reason the largest possible cylinder can be put into a given size of well casing.

The size of cylinders is rated by the diameter in inches and the length of the stroke. The following table may be found useful in deciding upon the proper size to use in any well. The different types of plungers and styles of valves are clearly shown in Fig. 17.

SIZE OF CYLINDERS AND SUCTION PIPE FOR WELLS OF VARIOUS DEPTHS.

Depth of Wells.	Size of Cylinders.	Size of Suction Pipe.
20 feet or less.	6 inches.	3 inches.
25 " "	5 "	2½ "
35 " "	4 "	2 "
50 " "	3½ "	1½ "
75 " "	3 "	1½ "
150 " "	2½ "	1¼ "
200 " "	2 "	1¼ "

CAPACITY OF PUMPS

The capacity of pumps depends on three things, namely, the inside diameter of the cylinder, the length of the working stroke and the number of strokes per minute.

The following table gives the capacities for cylinders two to six inches in diameter and on a basis of forty strokes per minute in case of 6-inch, 8-inch and 10-inch strokes.

Diameter of Cylinder in inches	Gallons raised per hour at the rate of forty strokes per minute to level of pump.		
	6-inch stroke.	8-inch stroke.	10-inch stroke.
2 inches	163	220	275
3 "	365	487	608
4 "	652	869	1,086
5 "	1,020	1,360	1,700
6 "	1,460	1,947	2,433

Rule for calculating capacity of a pump in gallons per minute.

Square the diameter of the cylinder in inches by length of stroke in inches by number of strokes per minute and divide the product by 352.

POWER PUMPING

The power required for pumping depends primarily upon two factors,—the weight of the liquid to be pumped per minute and the vertical height it has to be raised from the source of supply to the point of delivery. Besides this, allowance must be made in practice for the power needed to overcome the losses in the pumping outfit and the friction in the pipe lines.

Either of the following rules may be used to calculate the actual H.P. for pumping water.

$$\text{H.P.} = \frac{W \times H}{33000 \times E}$$

Where W is weight of water pumped in lbs. per minute, H is the total head in feet including friction in pipe lines, and E is the efficiency of the pump. E may be taken at 80 or 85%, or

$$\text{H.P.} = \frac{\text{G.P.M.} \times H}{3960 \times E}$$

Where G.P.M. = gals. pumped per min., H = total head and E is efficiency of the pump.

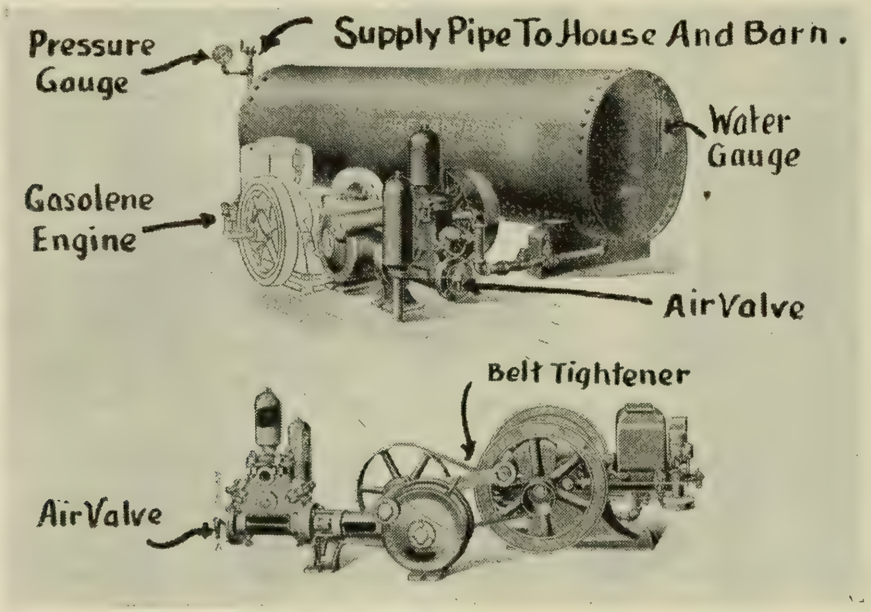


Fig. 18.—Heavy duty pumps with and without tank. Shallow well pumps will pump air and water.

FRICTION TABLE

Friction of water in pipes one-half to three inches in diameter and discharging one to fifty gals. per min.

LOSS OF HEAD IN FEET DUE TO FRICTION, PER 100 FEET OF NEW, SMOOTH WROUGHT IRON PIPE

Gals. per Min.	½-inch Pipe	¾-inch Pipe	1-inch Pipe	1¼-inch Pipe	1½-inch Pipe	2-inch Pipe	2½-inch Pipe	3-inch Pipe
	Fric.	Fric.	Fric.	Fric.	Fric.	Fric.	Fric.	Fric.
1	1.50							
2	5.30	1.40						
3	11.30	2.90	0.90					
4	19.20	5.00	1.52	0.40	0.19			
5	29.00	7.50	2.32	0.60	0.28	0.09	0.05	
10	105.00	27.10	8.40	2.18	1.02	0.36	0.12	0.05
15	....	57.00	18.90	4.65	2.25	0.81.	0.25	0.11
20	....	97.00	30.10	7.90	3.70	1.29	0.43	0.18
25	....	....	45.50	11.90	5.60	1.96	0.66	0.27
30	....	....	64.00	16.90	7.80	2.73	0.92	0.38
35	....	....	85.00	22.30	10.30	3.66	1.23	0.51
40	....	....	109.00	28.50	13.30	4.68	1.57	0.65
45	....	....	....	35.20	16.60	5.80	1.97	0.80
50	....	....	....	43.20	20.20	7.10	2.38	0.98

Suppose we wish to pump 30 gals. of water per min. against a combined lift and force of 200 ft., through a pipe two inches in diameter and 300 ft. long.

Friction loss in 100 ft. of two-inch pipe discharging 30 gals. per min. is according to the tables, 2.73 ft. Therefore for 300 ft. of pipe friction loss would be 2.73 x 3 = 8.19 ft. Adding this to the pumping head of 200 ft. the total head = 208.19 ft. W or weight of water pumped per min. is 30 x 10 (lbs. in 1 gal. Imperial) or 300 lbs. Take E to be 85 per cent.

$$\text{Actual H.P.} = \frac{W \times H}{33000 \times E} = \frac{300 \times 208.19}{33000 \times .85} = 2$$

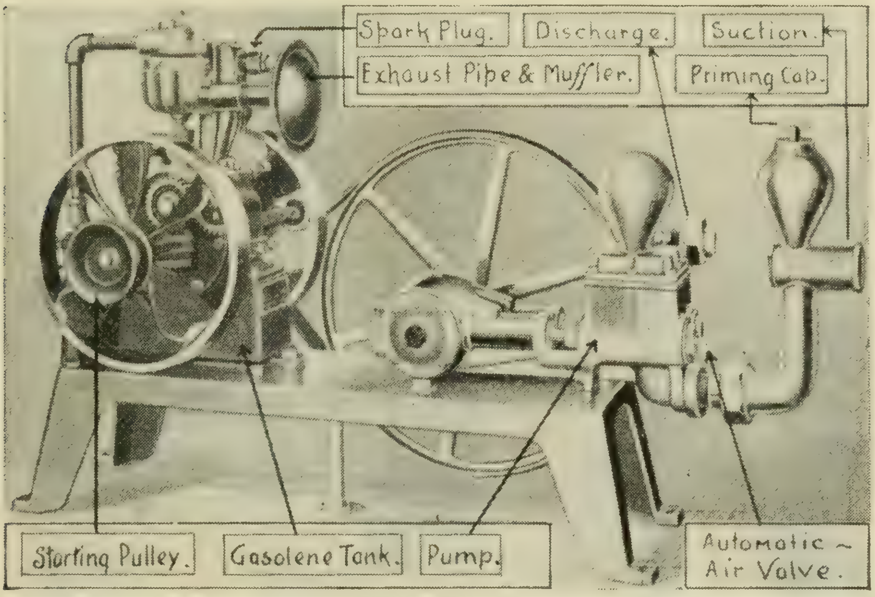


Fig. 19.—Pump run by air-cooled gas engine.

POWER REQUIRED FOR PUMPING WATER.

Under ordinary conditions very little power is required, as indicated for a few instances in the following table:

Size of Cylinder in inches.	Gals. pumped per hour on a 10-inch stroke.	H.P. for 100 ft. elevation.	H.P. for 200 ft. elevation.
2-inch	200	⅛	¼
3-inch	735	¼	½
4-inch	1,300	3/5	1
5-inch	2,000	4/5	1½
6-inch	2,935	1¼	2

NOTE.—The H.P. values given in the table are theoretical, to get the actual size of gasoline engine required multiply these values by two. Size of electric motor multiply them by one and a half.

PUMPING BY GASOLINE ENGINES.

Where electric power or windmill is not available, the gas engine is often used for pumping water into open or compression tanks. As seen in the preceding Power Table, only a very small engine is required. If desired, a cut-out device may be installed between the tank and the engine for the purpose of stopping the engine when the open tank is full, or in case a compression tank is used, when the pressure reaches 40 or 50 lbs. Fig. 18 shows a small water-cooled engine belted to a shallow well bulldozer pump for filling a large compression tank to serve both house and stables, lawn, etc. In Fig. 19 is illustrated a small air-cooled gas engine pumping unit. The pump is double cylinder, single acting, with a total capacity of about 400 gallons per hour. There is an automatic switch for stopping the engine when connected to tanks, as described above. The engine is easily started and operates very satisfactorily. It is practicable only on cisterns or shallow wells or wherever the unit can be placed within a twenty-two foot elevation of the water-level of the source.

PUMP JACKS.

In connecting up a gasoline engine to the ordinary well pump, either shallow or deep, some form of jack is required, common types being shown in Figs. 14 (*b*) and 20. They are back-geared at certain ratios, say five to one, eight to one, etc., so that the speed is reduced to give the proper number of strokes to the pump rod, provided that the right size of pulley is used on the engine. In the regular power pumps of modern design, both for shallow and deep wells, illustrated in Figs. 13 (*a* and *b*) and 14*b*, respectively, the gearing is wholly encased and runs in oil, which is an excellent feature.

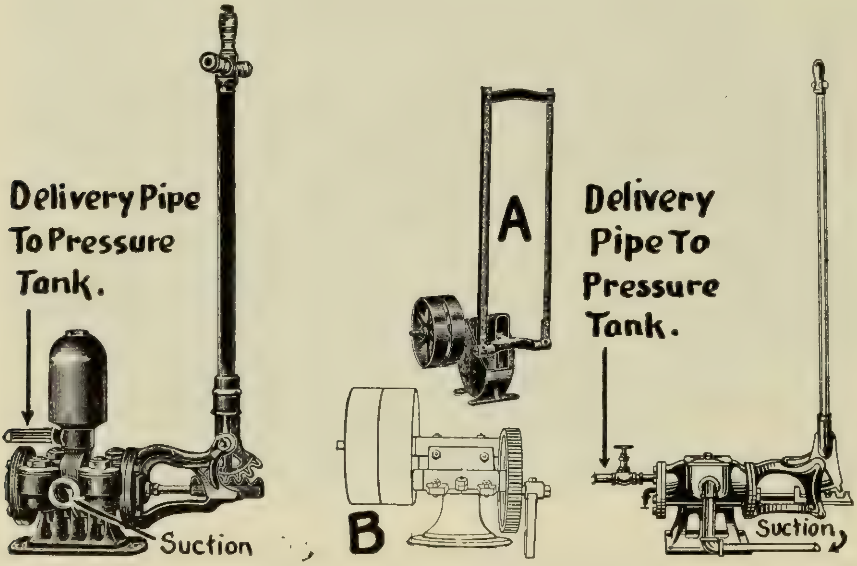

Delivery Pipe To Pressure Tank.
A
Delivery Pipe To Pressure Tank.
Suction
B
Suction

Fig. 20.—Two types of pressure tank pumps and Jacks.
A.—Suitable for vertical pumps. B.—For horizontal pumps.

How to Calculate size of pulley, either driver or driven.

Rules:—(1) $\text{Diameter of driven} = \dfrac{\text{speed of driver x its diameter}}{\text{speed of driven.}}$

(2) $\text{Diameter of driver} = \dfrac{\text{speed of driven x its diameter}}{\text{speed of driver.}}$

Problem:—An engine has a speed of 400 R.P.M. The pulley on the jack is twelve inches, the back gear is five to one. What size of pulley is required on engine to run pump at forty strokes per minute? The driven pulley in this case is the one on the jack, and its R.P.M. is 40 x 5 or 200.

Therefore diameter of driver (pulley on engine)

$$= \frac{200 \times 12}{400} = 6 \text{ inches.}$$

By following Rule 2 the diameter of the driven (pulley on jack) may be similarly calculated.

Pumping Water by Windmill.

Figs. 21 and 22

Another instance of power pumping is the use of the windmill. It is a very satisfactory method of pumping water, and as a result there is a very good demand for windmills. The best way to adapt their use to farm supply is to install a compression tank in the house and an open tank in the barn, the latter being supplied from the former. The operation is automatic, the wheel being pulled out of the wind when pressure in compression tank reaches 40 to 50 lbs. and reversed when it drops to 20 lbs. The newer designs of mills are much superior to the older ones, since the gears run in an oil bath requiring to be filled only once in several months, and frictionless bearings and other improvements have greatly increased its efficiency as a pumping power.

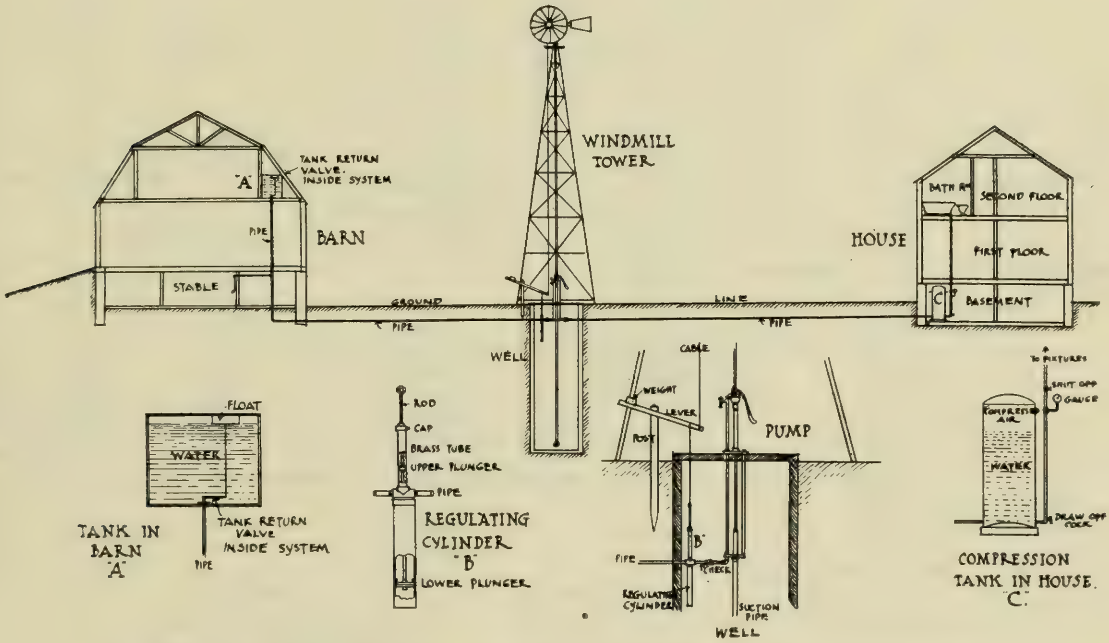


Fig. 21.—Windmill operating on compression and open water tanks.

The Pumping Capacity of Windmills.

The windmill depends upon the velocity of the wind for its power, and if there is no wind there is no power available. The strongest argument that can be used against the windmill is that it is no use in calm weather. This is true, and, therefore, the windmill cannot be used to drive any machine which would have to operate in all kinds of weather or at any time regardless of the weather. In respect to pumping water for domestic use, this objection or weakness can be largely overcome by using a storage tank or reservoir sufficiently large to hold three or four days' supply of water. In this country it is a rare thing to have more than a day or two of calm weather at one time, and therefore it is quite practicable to have a good supply of water on hand at all times if a reasonable amount of storage is provided for. For instance, in Canada the average velocity of the wind is eight miles per hour for from 5,000 to 6,000 hours, and approximately a 16-mile wind for about 3,000 hours, for, roughly speaking, ten hours per day. In other words, on the average over Canada there are from 208 to 250 days of the 365, or two out of three, when there is an 8-mile wind for ten hours each day, and 125 days, or more than one out of three, with a wind velocity of sixteen miles for a 10-hour period per day. In consulting Table I, it is seen that a 10-foot windmill operating with an 8-mile wind and with a 2-inch cylinder will lift 55 gallons per hour or 550 gallons per 10-hour period through a total elevation of 216 feet. This amount of water will meet the daily needs of a large household and about forty head of cattle, but the pumping is not quite fast enough to meet three days' requirements in two days, but according to the table a 2¼-inch cylinder would do so if elevation did not exceed 171 feet. Or making the same calculation with a 16-mile wind operating one out of three days we find by the table under column 15 miles (nearest to the 16-mile wind), that with a 2½-inch cylinder the water pumped would be 161 gallons per hour, or 1,610 gallons per ten hours through an elevation of 259 feet. This amount would be quite ample for three days' supply for the case under consideration. It would appear then that the wind blows frequently enough and hard enough to pump all the water the Canadian farmers require for their households, and their herds.

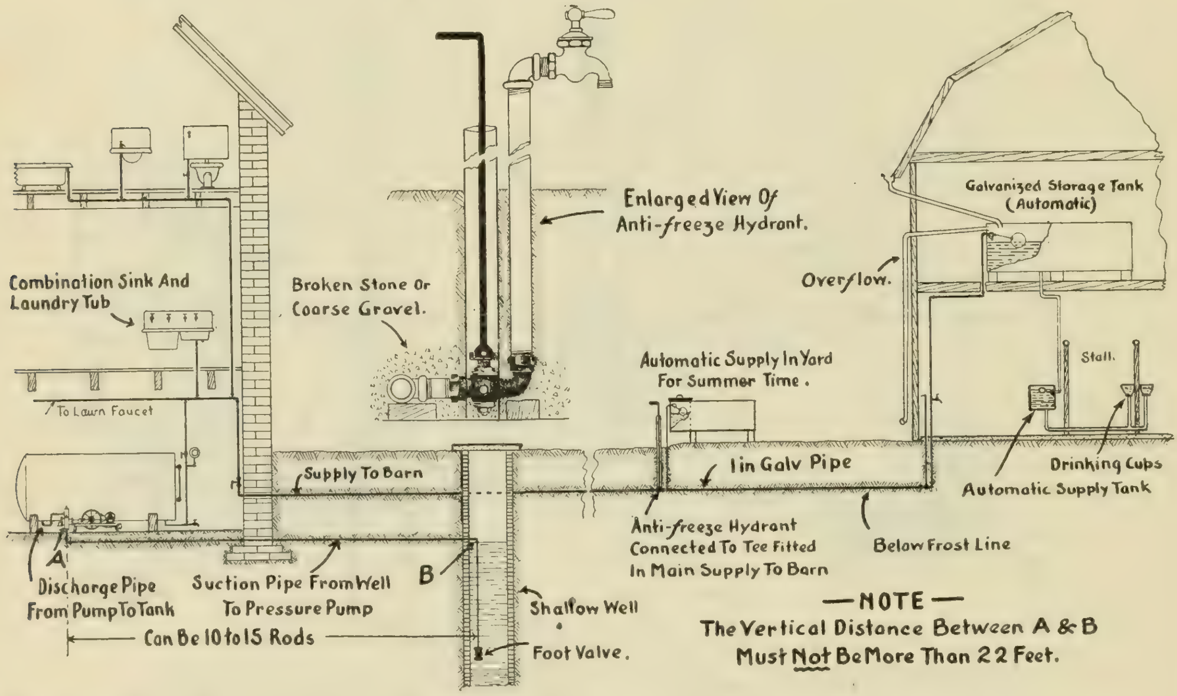

Enlarged View Of Anti-freeze Hydrant.
Galvanized Storage Tank (Automatic)
Combination Sink And Laundry Tub
Broken Stone Or Coarse Gravel.
Overflow.
Automatic Supply In Yard For Summer Time.
Stall.
To Lawn Faucet
Supply To Barn
1 in Galv Pipe
Drinking Cups
Automatic Supply Tank
A
B
Anti-freeze Hydrant Connected To Tee Fitted In Main Supply To Barn
Below Frost Line
Discharge Pipe From Pump To Tank
Suction Pipe From Well To Pressure Pump
Shallow Well
Can Be 10 to 15 Rods
Foot Valve.
—NOTE—
The Vertical Distance Between A & B Must Not Be More Than 22 Feet.

Fig. 22.—Barn supplied with water from house pressure tank and from barn roof.

At the Ontario Agricultural College, Guelph, Ont., a very accurate record of the wind's velocity and direction is kept, and the records of average velocity are as follows:—January, 12.5 miles; February, 12.3; March, 12.0; April, 13.0; May 11.0; June, 8.5; July, 6.4; August, 7.0; September, 7.8; October, 11.0; November, 12.5; December, 10.2. These figures are interesting for two reasons,

—first, in showing that there is enough of wind to pump all the water the farmers need; and second, that the wind is strongest during the months when the cattle are in the stables and more water is needed at the buildings than in the summer when, as a rule, the stock drink from other sources of supply out in the pastures.

TABLE SHOWING GALLONS PUMPED PER HOUR AND TOTAL ELEVATION THAT WATER CAN BE RAISED WITH DIFFERENT CYLINDERS AND DIFFERENT WIND VELOCITIES BY 8-FOOT AND 10-FOOT MILLS.

Diameter of Cylinder in inches.	Wind Velocities per Hour.							
	8 miles		10 miles		12 miles		15 miles	
	8-ft. mill.	*10-ft. mill.*	*8-ft. mill.*	*10-ft. mill.*	*8-foot. mill.*	*10-ft. mill.*	*8-ft. mill.*	*10-ft. mill.*
2	111 ft.	216 ft.						
	delivering 55 gallons.							
2½	71 ft.	138 ft.	89 ft.	173 ft.	106 ft.	207 ft.		
	delivering 86 gallons.		delivering 107 gallons.		delivering 129 gallons.			
3	49 ft.	96 ft.	61 ft.	120 ft.	74 ft.	144 ft.	92 ft.	180 ft.
	delivering 123 gallons.		delivering 154 gallons.		delivering 185 gallons.		delivering 231 gallons.	
3½	36 ft.	71 ft.	45 ft.	86 ft.	54 ft.	106 ft.	68 ft.	132 ft.
	delivering 168 gallons.		delivering 210 gallons.		delivering 252 gallons.		delivering 315 gallons.	

NOTE.—To get the pressures corresponding to these elevations, divide by 2⅓.

POWER DEVELOPED BY WINDMILLS OF VARIOUS SIZES AT DIFFERENT WIND VELOCITIES.

Wind Velocity in miles per hour.	Size of Windmill.			
	8 ft.	10 ft.	12 ft.	16 ft.
8	.084	.164	.28	.67
10	.132	.257	.44	1.05
12	.189	.370	.64	1.52
15	.296	.580	1.00	2.37
20	.530	1.030	1.78	4.21
25	.820	1.610	2.78	6.58

PUMP TROUBLES AND HOW TO REMEDY THEM.

1. If pump fails to deliver water first see if there is any water in the well or not.

2. If pump loses its prime, the suction valve (see lower valve, Fig. 16 (*b*)) is defective or something has lodged under it and preventing it from closing tightly. Remedy is to repair or clean it.

3. If pump is delivering a good deal of air and too little water, there is an air leak in the suction line or cylinder, probably a loose joint or hole in pipe, or well is running dry.

4. If the handle works up and down without apparent resistance, and delivers little water or none at all, it indicates that the plunger leather is worn and not creating a vacuum in cylinder, or else suction valve is not working

properly. Probably suction pipe is too low or well is filling up. Remedy is to take pump apart and make necessary repairs.

5. If pump works hard or handle jerks up when pushed down, it is evident that something is preventing the water rising in the suction pipe to cylinder. This may be due to too long or too small a suction pipe, or end of pipe is choked by something in bottom of well.

6. If a lift pump and the water splashes out at the top of pump, it is a sign that the cylinder is too large for the head. If pump is taking in air below the cylinder, it will also have a tendency to do this.

7. In power-driven pumps, types used on compression water systems, for example, may become noisy. This is due to dirty valves or one or more valves sticking fast. Or dirty strainer may cause pump to pound. Another case where noise will develop is where the suction line loops upward, for example, extending upwards and over the top of the cistern wall and then down to pump on floor. The remedy here is to put an air-chamber at the highest point, a two-inch pipe about eighteen inches long will serve all right for air chamber in this case.

NOTE.—A knowledge and an application of these few principles would increase the efficiency of farm pumps, generally speaking, fully 50 per cent.

THE HYDRAULIC RAM.

Meriman in his "Treatise on Hydraulics" describes the hydraulic ram as follows: "It is an apparatus which employs the dynamic pressure produced by stopping a column of moving water to raise a part of this water to a higher level. The principle of its action was first recognized by Whitehurst in 1772, but the credit of perfecting the machine is due to Montgolfer, who in 1796 built the first self-acting ram."

The chief purpose of the hydraulic ram is to lift spring water for domestic purposes on farms and large estates. Under special conditions it may be used on a larger scale to supply water for irrigation, railroad watering stations, etc.

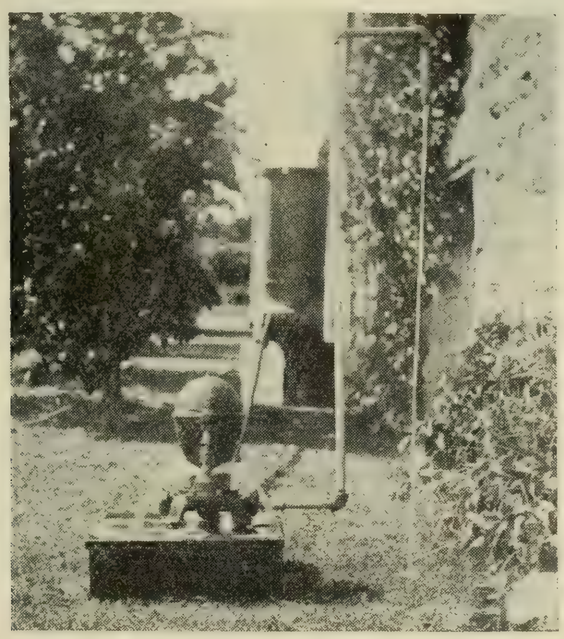


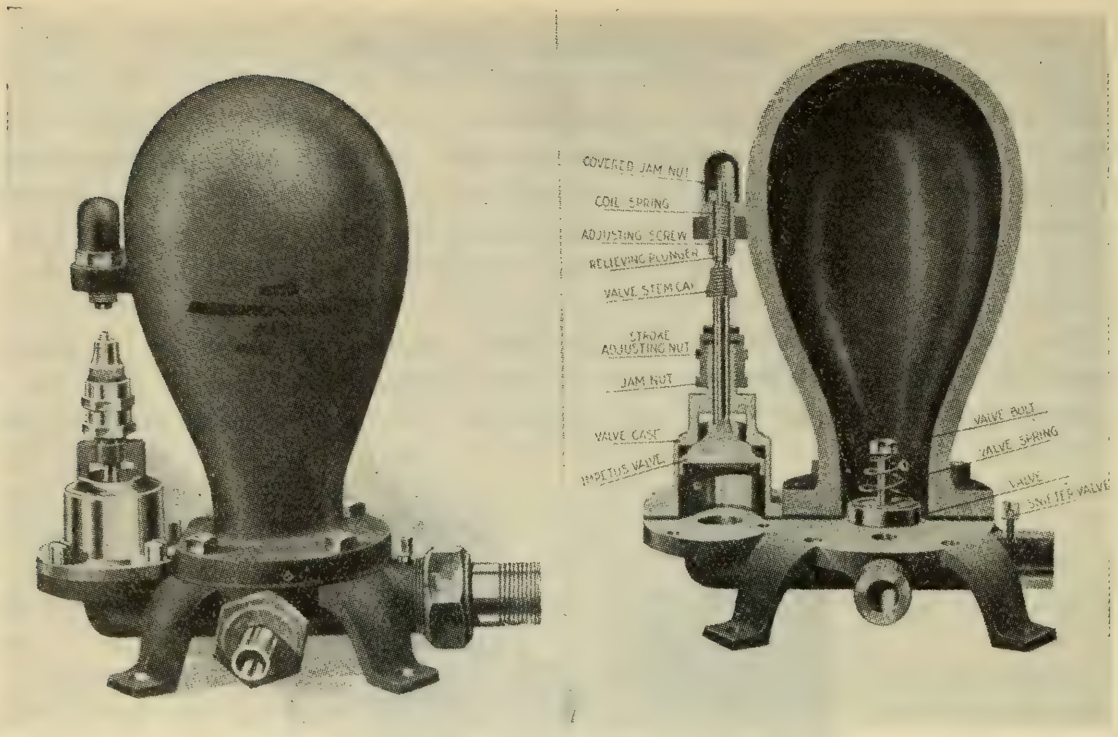
Fig. 23.—Hydraulic ram on test at O.A.C. Guelph.

It has many advantages, chief of which are that it is automatic in operation, requires practically no attention, needs no oiling, does not depend upon the wind, has little cost of maintenance, and it will last indefinitely with reasonable care.

THE CONSTRUCTION OF THE HYDRAULIC RAM.

For those who are not familiar with the hydraulic ram, a few words regarding its construction may be appreciated. The particular design described herein is commonly known as the standard hydraulic ram, being the one which our Department has given special study both in the laboratory and in actual service on many farms. There are, however, other types which give equally good service.

The design and construction of the ram itself may be clearly understood from a study of Figs. 23 and 24. The parts are the base comprising the inlet and discharge pipes, the two valve parts, and the four feet; the air dome with relief plunger attached, the waste valve or the cone-shaped part above the lower end of the drive-pipe, the valve at the base of the air dome and the air or snifter valve. The various parts of the waste valve are clearly shown in Fig. 24 (*b*). In Fig. 23 the ram is shown in action, and in drawing, Fig. 25, the details regarding the actual installation are outlined.



a

b

Fig. 24.—(a) The standard hydraulic ram in perspective. (b) Vertical section of same.

The Principle, or How the Ram Works.

Keeping Fig. 26 in mind, the principle may be clearly understood by the following description:

When the water flows down the drive pipe it finds the valve C closed and W open on account of their own weight, consequently it begins to escape through the open waste valve. As soon as the velocity of the water is great enough to counterbalance the weight of the valve W, the latter closes, and very suddenly,

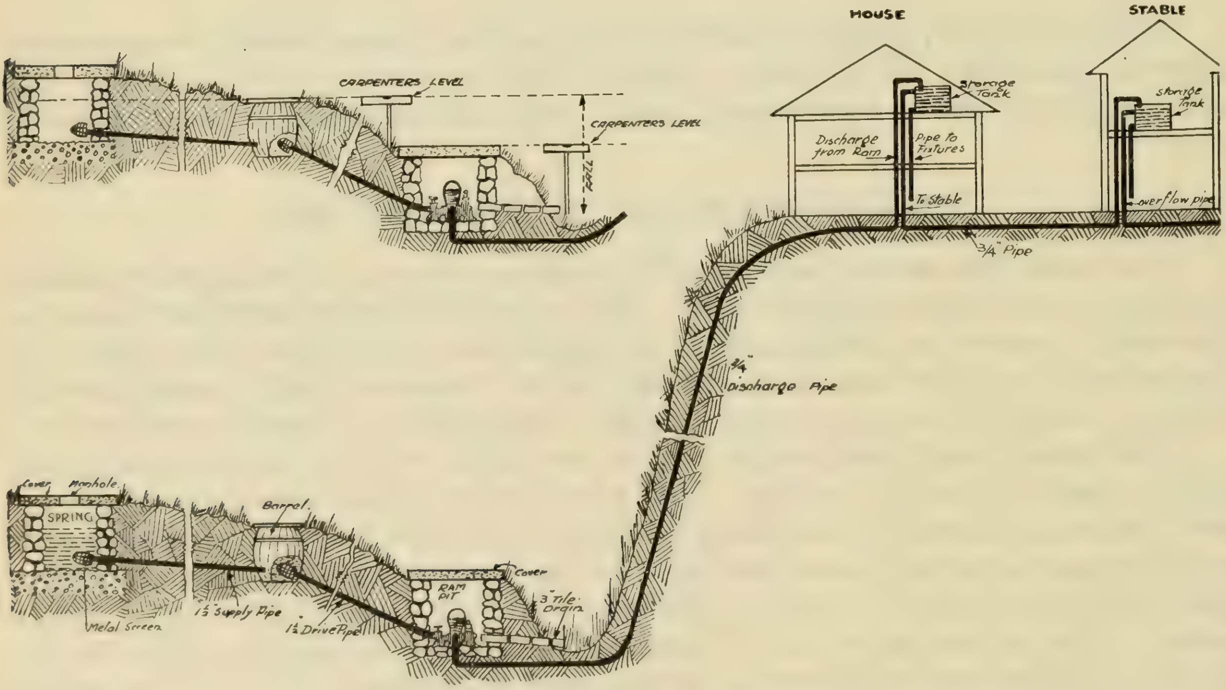


Fig. 25.—A typical hydraulic ram installation.

too. If the drive pipe D is 1½ inches in diameter and fifty feet long, which is a length frequently used, the weight of water in the pipe is thirty-eight pounds, and this is moving rapidly down the pipe. When the waste valve closes suddenly the thirty-eight pounds of water strikes a blow on the inside of the pipe, including the valve C. Think of the blow a thirty-eight-pound hammer would strike, and

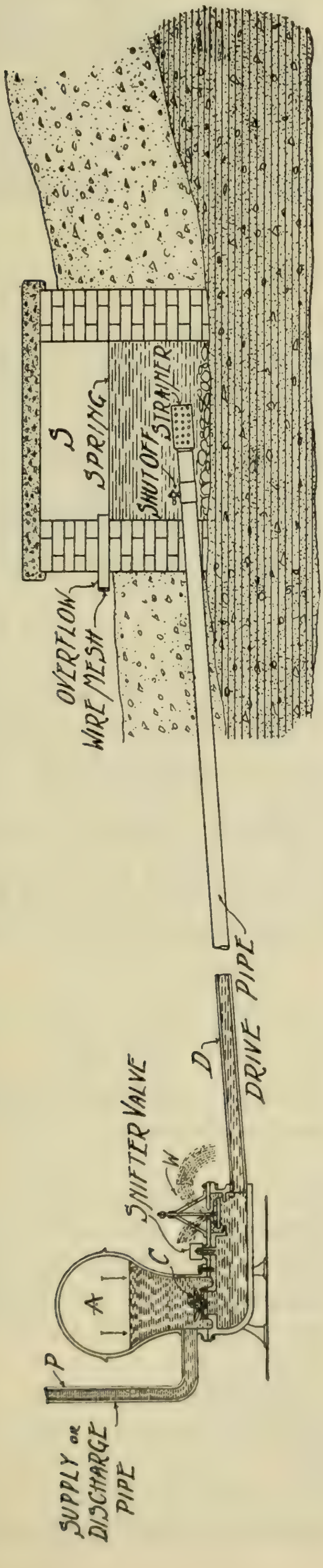


Fig. 26.—Sectional diagram of hydraulic ram installation.

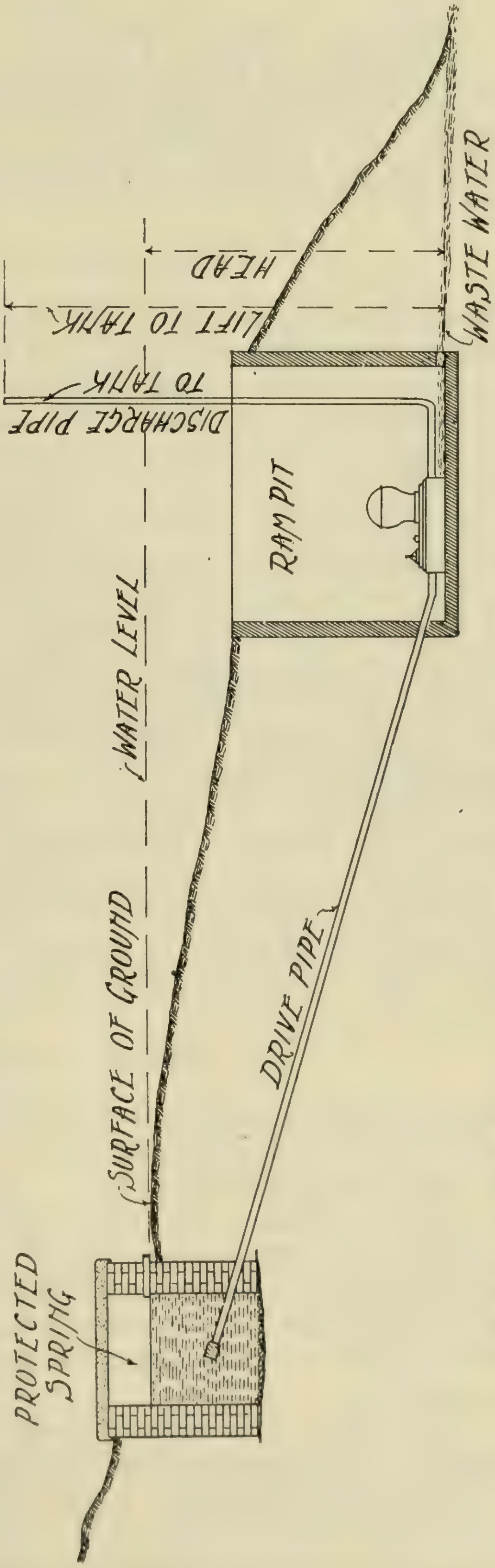


Fig. 27.—The hydraulic ram installation under ordinary conditions, ram close to spring.

you have some idea of the blow delivered by the water. The impulse opens the valve C and the water rushes suddenly and rapidly into the air dome A. By and by, however, it comes to rest on account of the back pressure of the air. Immediately this happens the air begins to expand and starts the water backward up the drive pipe. This lasts only an instant, just long enough for the check valve to close, but this small recoil is a very important factor in the working of the ram. When the check valve closes, the movement of the water backward in the pipe creates a suction on the waste valve, which, along with its own weight, opens the valve. Meantime, the air in A continues expanding and drives the water at a steady rate up the supply pipe toward the buildings. While this is taking place the water is wasting through W, and as soon as the velocity is great enough, W is closed again and another blow is struck, and thus the whole cycle is repeated over and over again.

THE PURPOSE OF THE AIR-DOME.

The air-dome is absolutely essential to the working of the ram. In the supply pipe leading away from the ram up to the buildings there is a large weight of water, and even the blow from the thirty-eight-pound hammer in the drive pipe couldn't set all that water in motion so suddenly. But in the dome is a cushion of air, and when the blow comes that cushion is easily and quickly compressed, allowing a volume of water to rush in suddenly, irrespective of the water in the supply pipe. However, since air is soluble in water, the quantity in the dome gradually disappears and when nearly all exhausted the ram will stop working, and the only way to start it again is to put fresh air into the dome. To do this it may be necessary to remove and empty it. Some drill a hole in it and put in an air valve similar to those used in bicycle or automobile tires, and then by means of a hand-pump force fresh air into the dome from time to time. However, it is possible to have air taken in automatically. It has already been pointed out that immediately after the valve C closes, a suction is created in the drive pipe. If a small hole is drilled in it, preferably on the top side, and essentially close to the ram, then at each suction a few bubbles of air will be drawn in, and this will keep the air in the dome constantly replenished. During the pressure portion of the stroke, some water will waste through this hole, and, consequently, in new rams a check valve is fitted into it to prevent loss of water but admitting air. This is sometimes called a snifting, snifter, or sniff valve.

MAKING A RAM SURVEY.

Anyone considering the installation of the hydraulic ram should familiarize himself with the conditions under which it can be used successfully, or make a survey. They are as follows:

1. Supply of Water. It varies with size of ram used, the smallest size, No. 2, using at least 2 gallons per minute; No. 4, the commonest size, eight or ten gallons per minute. It is necessary first of all to measure the flow from the spring in order to make sure there is water enough. Do not guess at it, but actually measure the overflow of the spring by noting how long it takes to fill a pail of a known capacity.

2. Fall or Head. The water operating the ram must have a fall into the ram. It will operate under a head as low as eighteen inches, but usually much more than this is required to lift the water to the desired elevation. The lift is ten feet for every foot fall, so that five or six feet, at least, are required, sometimes more. The actual fall may be determined by use of the carpenter's level, as shown in

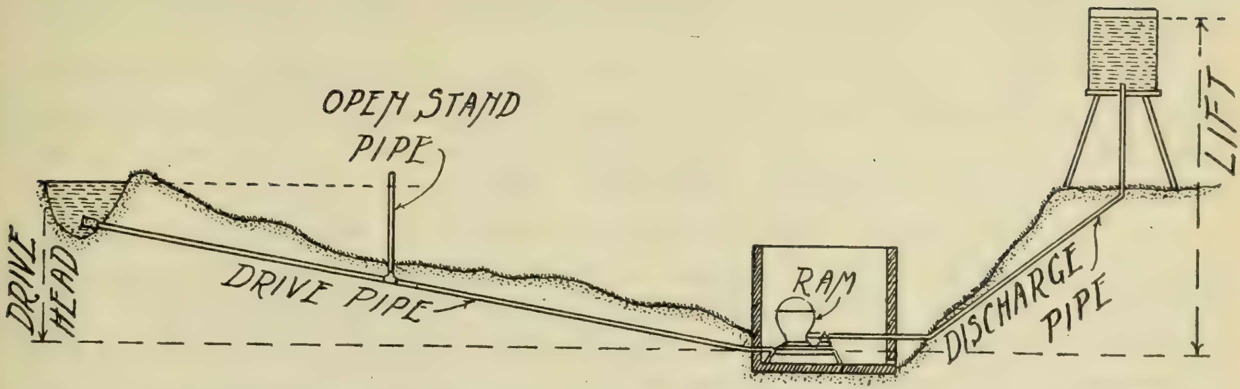


Fig. 28—When the ram is at considerable distance from the spring, an open stand pipe or reservoir must be provided within 35 to 50 ft. from the ram.

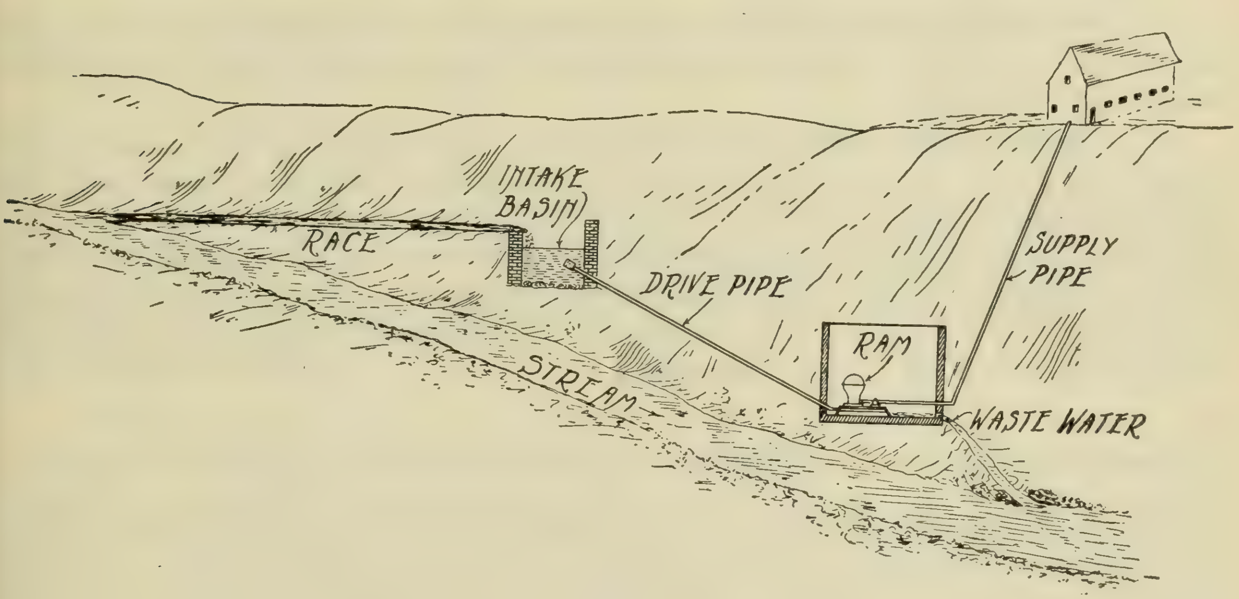


Fig. 29.—Obtaining head for ram along a river bank.

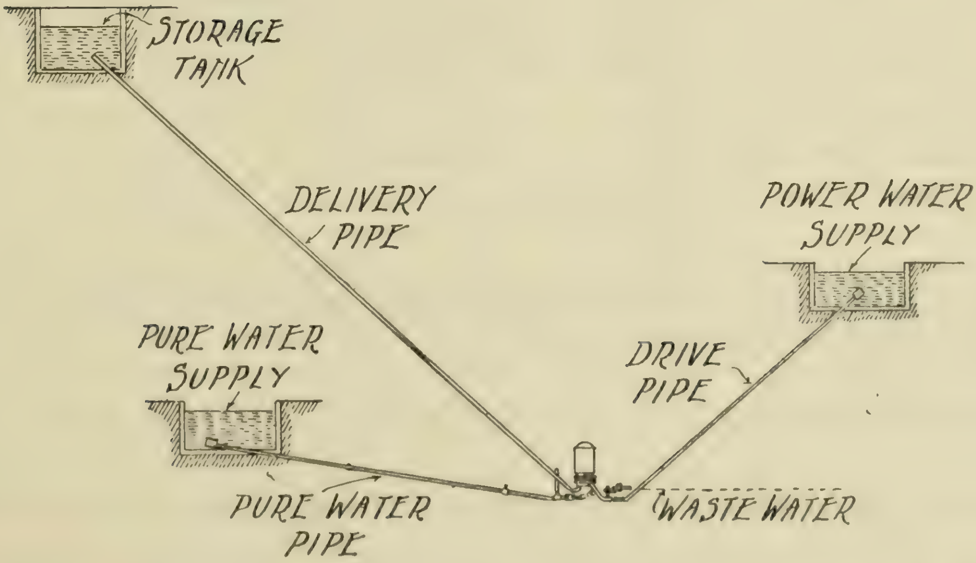


Fig. 30—Double acting ram using impure water supply to drive pure water to the buildings.

Fig. 25. The head may be increased by damming back the source or sinking ram pit or both.

3. *Drainage.* A great deal of water wastes from the valve, as indicated in Fig. 23, and as flooding would stop the ram it is necessary to have good drainage from the bottom of the ram pit, and in placing the ram this fact must be kept in mind and proper drainage provided for. See Figs. 25 and 27.

4. *The Pipe Lines.* The drive-pipe should be laid on a uniform grade and without any turns or sharp angles. In fact, it should follow a direct course between the spring and the ram. Angles in the discharge pipe are not so objectionable. The length of the drive-pipe should be not less than five or six times the amount of fall or less than three-quarters of the lift. It may be more, however, but if length exceeds 100 feet or so an open stand-pipe should be attached to the drive-pipe about fifty feet from the ram, and extending upwards slightly higher than the source, as shown in Fig. 28. Fifty or seventy-five feet is a very satisfactory length of drive-pipe.

5. *Housing the Machine.* In cold climates the ram should be put in a pit two or three feet deep, and all pipes laid below the frost line in order to avoid any possibility of freezing.

6. *Constand Head.* The ram works rather better if the head of water or fall is kept constant, and this can be done by installing a barrel or some sort of a tank with an overflow a little way below the spring, piping the water to it and connecting the drive-pipe of the ram to this tank instead of to the spring directly, as illustrated in Fig. 25. There should be a depth of at least twelve inches of water over the entrance to the drive-pipe to prevent air entering the pipe and stopping the machine. (See Appendix I.)

AMOUNT OF WATER THE RAM WILL DELIVER AND HOW TO CALCULATE IT.

Where conditions are suitable for a ram it is without question the cheapest and most satisfactory method of pumping water. It has one drawback—it wastes far more water than it pumps to the buildings, and hence can only be installed where the supply is from five to twenty times as great as required at the buildings. The efficiency of the ram is from sixty-five to ninety per cent., i.e., it uses sixty-five to ninety per cent. of the energy of the falling water. Suppose the spring supplies ten gallons per minute and the fall from the spring to the ram is five feet. Multiply these together and then take sixty-five per cent. of the product, and we have the energy available for driving water to the buildings.

$$\text{Energy in this case} = \frac{65}{100} \times 10 \times 5 \text{ foot gallons.}$$
$$= 32.5 \text{ foot-gallons.}$$

Now divide this by the height of the buildings above the ram and we have the number of gallons the ram will deliver per minute at the buildings. If, for example, the height is 32.5 feet, then

$$\text{Number of gallons delivered per minute} = \frac{32.5}{32.5} = 1 \text{ gallon which is } 1/10 \text{ of}$$

the water supplied by the supposed spring. In ordinary usage about one-seventh of the water is lifted.

Therefore number of gallons per day $= 60 \times 24 = 1{,}440$ gallons = about twenty-nine barrels. Consequently with 5 feet of head and 32.5 feet of lift the ram will deliver at the buildings one-tenth of the water in the spring. The quantity that will be delivered with other heads, lifts and spring flows may be calculated in a similar way.

GENERAL FORMULA.

$$Q=\frac{S\times H}{L}\times E$$

where Q = gallons pumped per minute.
S = supply in gallons per minute.
H = head or fall in feet.
L = lift above the ram in feet.
E = efficiency, average value being 65%.

If $E=50\%$ then $Q=\frac{S\times H}{2L}$, which will give approximate result.

Note.—To get amount pumped per day multiply result by 60 and 24.

SPECIAL TYPES OF INSTALLATION.

No. 1.—The Ordinary Type. This is illustrated in Fig. 27 below, or where the conditions are such as to allow of building a ram pit within thirty-five to fifty feet of the spring, low enough to give sufficient fall in the drive pipe, and at the same time affording ample escape for the waste water. Note method of protecting the spring.

No. 2.—Ram far away from spring. Sometimes the ram pit must be built a considerable distance from the spring—say 200 feet. With such a long drive pipe the ram will not work satisfactorily unless fitted with an open stand-pipe about thirty-five to fifty feet from the ram, as shown in Fig. 28. Sometimes a reservoir is used instead of the stand pipe, e.g., a barrel sunk in the ground. A long drive pipe is a detriment, for two reasons; first, friction is so great in it that it takes considerable time for the water to get up sufficient velocity to close the waste valve; secondly, the air expansion in the dome would have to start all the water in 200 feet backward up the pipe before any recoil and suction could take place to aid in reopenng the waste valve. The stand pipe overcomes both these difficulties—during the recoil the water in the lower section of the line recoils up the stand-pipe while above it the water still keeps flowing down the line and raising the level in the stand pipe. When the waste valve opens again the supply and head in the stand pipe enables the water in the lower section to develop velocity quickly independent of that in the upper section. Thus the water level in the stand pipe pulsates up and down.

No. 3.—Ram installed alongside a stream serving as source. On a stream where head is not available under existing conditions, it is sometimes possible to lead a portion of the water by a ditch or tile along the bank at a slower grade than the stream itself, and so obtain the necessary head. This is illustrated in Fig. 29.

No. 4.—Double acting hydraulic ram. Sometimes a small pure spring which does not supply sufficient water to operate a ram is situated near another source of water unfit for domestic use, as a pond, lake or stream. When the levels are such that the two supplies can be led together at a lower point, a double-acting ram may be used. This is so constructed that the impure water operates the ram and delivers nearly all the spring water at the buildings. Fig. 30 shows this installation.

Further particulars regarding this rate type of installation will be given on application if required.

How to Maintain Successful Operation of the Hydraulic Ram.

1. *Keep air chamber well supplied with air.* Air is absorbed by the water, or it may escape through a tiny hole in the chamber. See that the air valve, designated snifter valve in Fig. 24, does not get clogged. A water-logged air chamber is one of the main causes for ram ceasing to operate.

2. *The valves should be kept in good repair.* Broken or worn valves will cause ram to stop. Foreign matter may lodge in the valves and prevent proper seating of the valves, a leak resulting. A strainer on inlet to drive-pipe will help to keep out dirt, leaves, sticks, etc.

To test the waste valve pull it up tightly and hold it for a moment. If on releasing it the valve remains closed and does not leak, one may rest assured that the valve is all right.

To test the valve in the air chamber, shut the water off the drive-pipe by closing the gate valve near the ram, and hold the waste valve open. If delivery valve is leaking water will come out at the waste valve.

3. *Adjust length of stroke of waste or dash valve to suit supply of water.* The larger the stroke, the greater is the capacity of the ram. Therefore, if supply increases lengthen the stroke and vice versa in order to keep the machine working at its greatest efficiency. See Fig. 24 (*b*) for position of adjusting nut.

Storage Tank.

Since the ram pumps very slowly, it is necessary to have a reservoir or storage tank of some kind at or in the buildings so that plenty of water will be on hand at all times. If water is used for both house and barns, the best method is to have a storage tank in the attic of the house and pump directly into it, allowing the overflow to go to another tank in the barns or into troughs in the stables or sheds, as illustrated in Fig. 25 below.

The Cost of Installing an Hydraulic Ram.

As the installations vary considerably in size, no stated cost can be given, but by reference to the subjoined table the cost of any particular outfit can be easily calculated.

THE STANDARD HYDRAULIC RAM.

Table of Capacities, Prices, etc.

Sizes	Minimum amount of water in gals. per min. to operate Ram.	Length of drive pipe.	Diameter of Pipes.				Price of Ram.
			Drive.		Discharge.		
2	2	not less than 5 to 6 the fall or head.	¾ in.	$9 66	½ in.	$8 03	$19 50
3	4		1 in.	13 87	½ in.	......	19 50
4	8		1½ in.	18 77	¾ in.	......	24 60
5	14		2 in.	30 20	1 in.	......	30 60
6	25		2½ in.	47 75	1¼ in.	17 07	49 20

Note.—Prices of black pipe are about 25 per cent. less than galvanized.

Cost of a Typical Installation.

Size 4 ram is the most common one in use, and to install it complete with fifty feet of drive pipe and 100 feet delivery pipe costs about $65.00, this total being made up about as follows:

Details of Cost.

1 ram, No. 4	$24 60
50 ft. 1½-inch drive pipe (galvanized)	9 38
100 ft. ¾-inch discharge pipe (galvanized)	9 66
One 1½-inch gate valve	5 00
Trenching, laying pipe and refilling trenches	6 00
Ram-pit	5 00
Cribbing spring, etc	5 00
	$64 64

Each additional 100 feet of discharge pipe installed would cost about $14.00.

WATER SUPPLY FOR FARM HOME.

Man's three greatest daily needs are clothes, food and water, not the least of these by any means is water. The farmer and his family have been, and are still in too many instances, handicapped in the use of water, not altogether because it has not been available in the well or other sources, but in that it has been necessary to carry it from the source into the house and stables. This condition has entailed a great deal of time and inconvenience, and restricted, no doubt, the quantity used for the various needs for water.

The Department of Agricultural Engineering appreciates the opportunity of examining, either personally or by correspondence, the requirements and other conditions of the farm home before the family decides on any plan or procedure. We feel that if we know these things that we can help them a great deal. Make good use of Appendix II, on page 81.

Water Consumption on the Farm.

The quantity of water used about a place depends on the size of the family the head of stock kept, the supply available, and whether or not the water has to be carried from the well, or is "on tap" wherever needed, and the extent to which complete plumbing is installed in the home.

In computing the approximate amount of water required in any case, the following data may serve as a useful guide.

Water carried	8 gals. per person per day.
Pump at kitchen sink	10 " " "
Faucet at kitchen sink	12 " " "
Running hot and cold water in kitchen	18 " " "
Complete plumbing with water under pressure	30 " " "
Bathtub*	8-20 gals. each time used.
Closet*	35 " " " "
Lavatory (wash basin in bathroom)	1-2 " " " "
Sprinkling lawn	8 gals. per 100 square feet.
Soaking lawn	20 " " " "
Cow	10 gals. per day.
Horse	10 " "
Hog	2 " "
Sheep	½ " "

*Water for these purposes is included in the item above entitled "Complete Plumbing and Water under Pressure."

SYSTEMS.

The Modern Compression System versus the Gravity System.

In these days no system can hardly be termed a real water system unless it actually provides for running water or water "on tap" at the points of service. There are only two ways of securing this, namely, by pumping water to a tank of some kind located well above the level or places where the water is required and piping it down to the outlets, the other is to use an enclosed air-tight tank and force water into it, thereby reducing the original volume of air and increasing its pressure, or in other words, the water is stored against air pressure which forces out the water when any outlet is opened. The former system has been

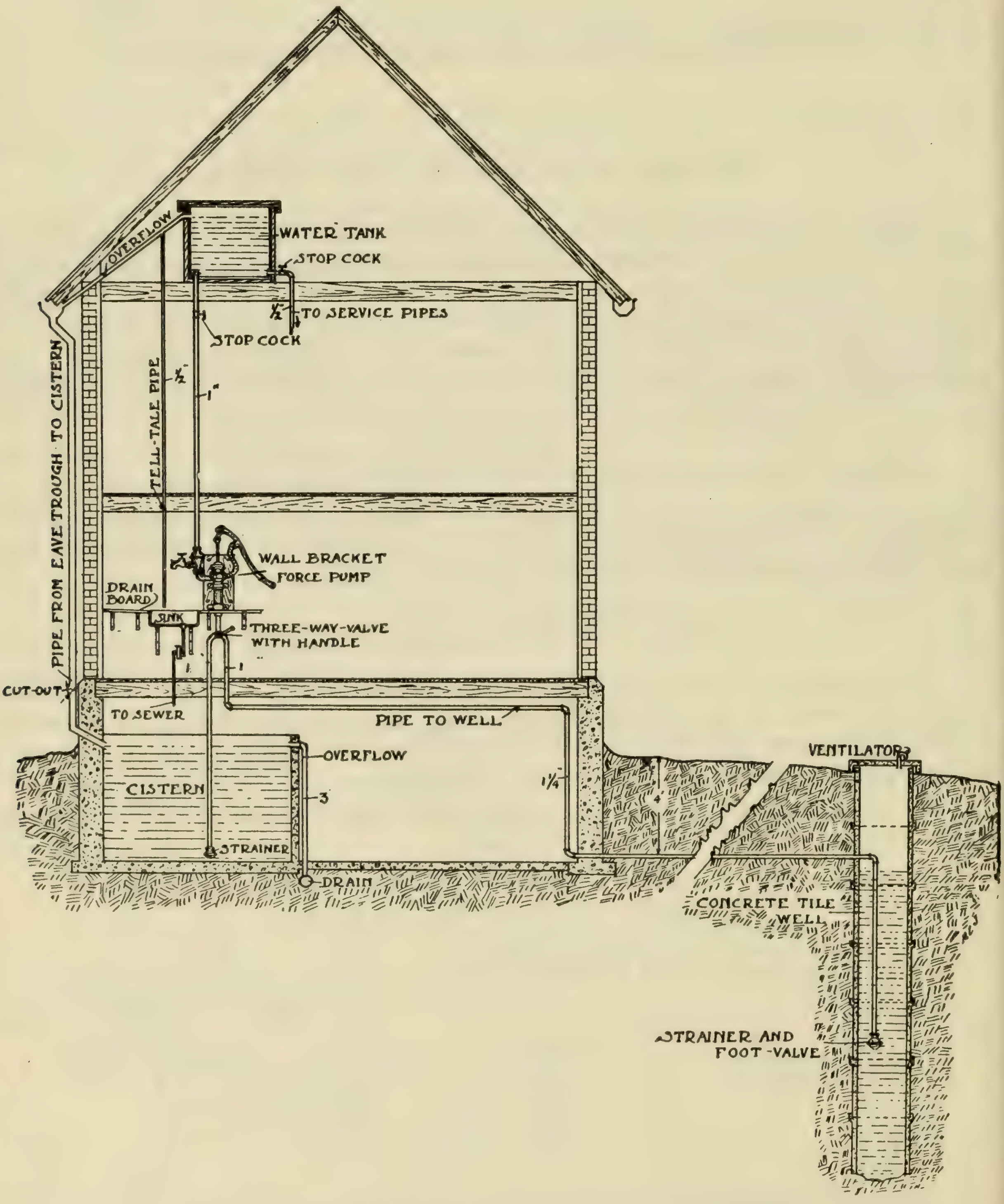


Fig. 31.—Cistern and attic tank system of water supply.

used considerably in the past with very good results and is commonly known as the *attic tank system or gravity system.* Fig. 31 shows its main features. The latter one is called the *compression or hydro-pneumatic water system.* We recommend this system very highly for general adoption, and the only system to install where the pumping is done by electric motor or any automatically controlled power. Figs. 32 to 39 illustrate the principles on which it operates, and show several common types of installations.

Some Special Features of the Compression System, Particularly of the Electrically Driven Units.

1. They give very reliable and efficient service at very low cost of operation and maintenance.

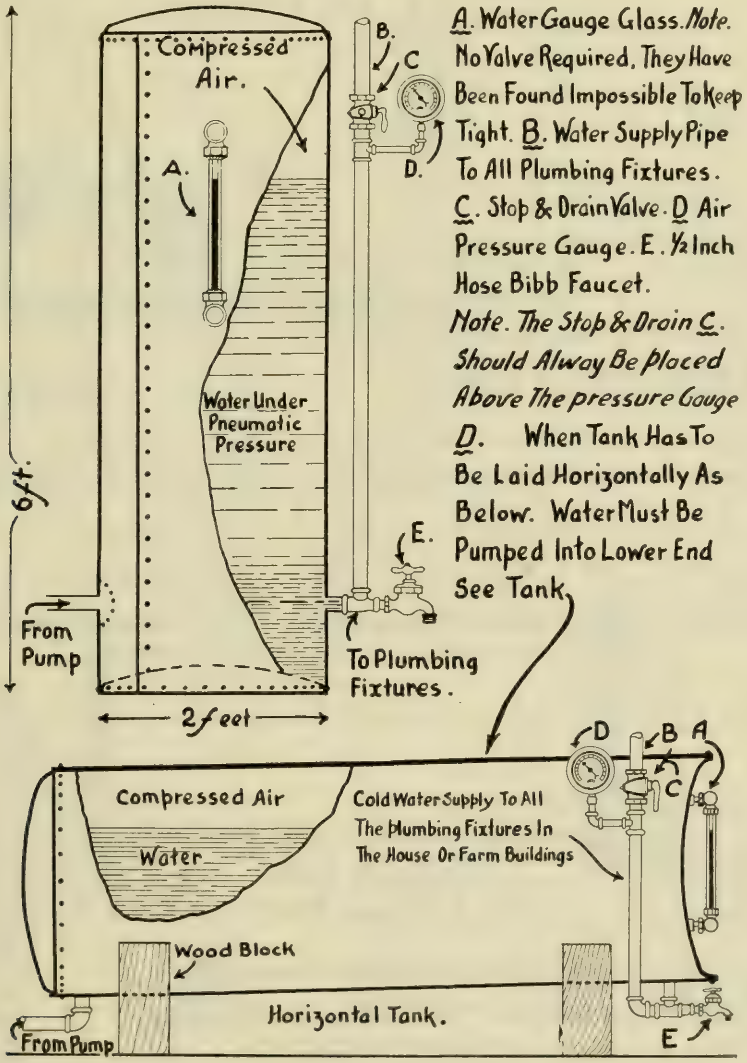

Compressed Air.
A.
Water Under Pneumatic Pressure
From Pump
6 ft.
2 feet
B.
C
D.
E.
To Plumbing Fixtures.
A. Water Gauge Glass. Note. No Valve Required. They Have Been Found Impossible To Keep Tight. B. Water Supply Pipe To All Plumbing Fixtures. C. Stop & Drain Valve. D Air Pressure Gauge. E. ½ Inch Hose Bibb Faucet.
Note. The Stop & Drain C. Should Alway Be Placed Above The pressure Gauge D. When Tank Has To Be Laid Horizontally As Below. Water Must Be Pumped Into Lower End See Tank.
D
B
A
C
Compressed Air
Water
Cold Water Supply To All The Plumbing Fixtures In The House Or Farm Buildings
Wood Block
Horizontal Tank.
From Pump
E

Fig. 32.—Principle governing pneumatic pressure water systems for farm and rural homes.

2. Water is stored in an air-tight tank which preserves its purity, and as tank is usually located in the cellar or beneath the ground, the water is not likely to freeze in winter or become too hot in summer.

3. A pressure varying from twenty to forty-five pounds is available for ordinary service, more if necessary for special purposes. Therefore quick service is provided at all times.

4. In case of the electrically operated units, either the shallow or deep well outfits, a fresh water attachment is possible for a few extra dollars for the pur-

pose of supplying drinking water direct from the well. See Fig. 37 for details of this arrangement.

5. The automatic feature of the electrically driven systems is a strong one, as it provides for continuous service at good pressure, a smaller tank will do,

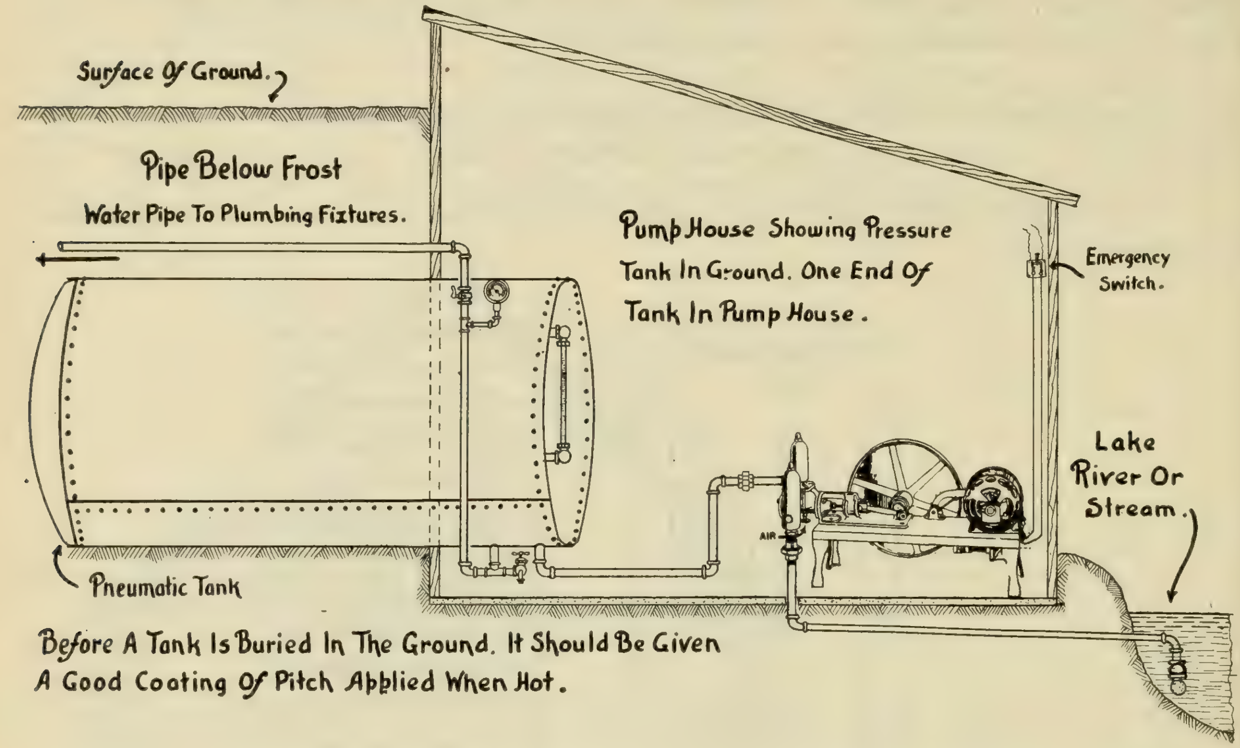

Surface Of Ground.
Pipe Below Frost
Water Pipe To Plumbing Fixtures.
Pump House Showing Pressure Tank In Ground. One End Of Tank In Pump House.
Emergency Switch.
AIR
Lake River Or Stream.
Pneumatic Tank
Before A Tank Is Buried In The Ground. It Should Be Given A Good Coating Of Pitch Applied When Hot.

Fig. 33.—Complete water system in small pump house situated near source of water.

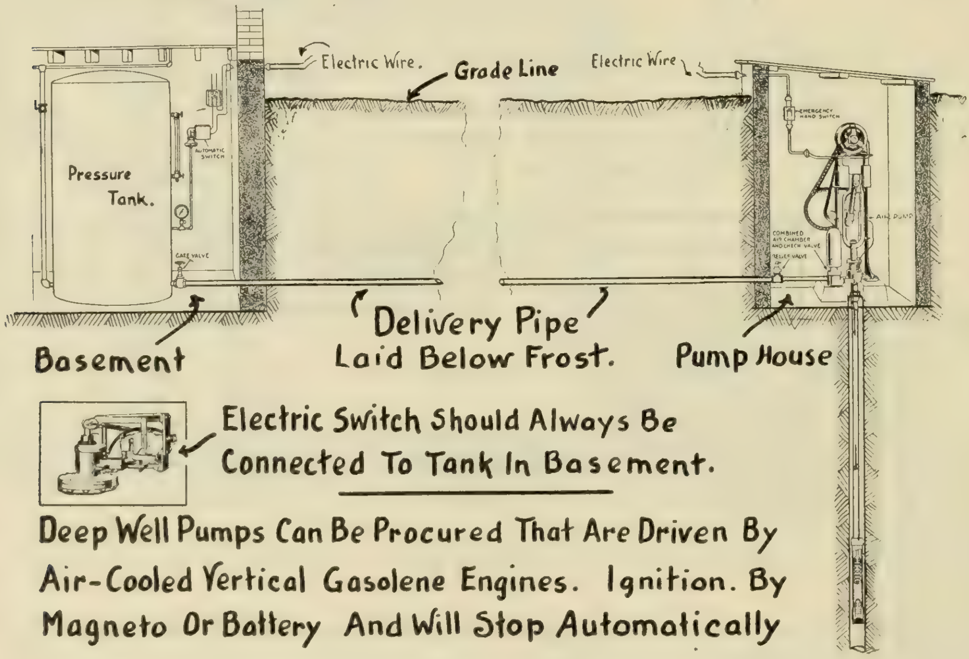

Electric Wire.
Grade Line
Electric Wire
Pressure Tank.
AUTOMATIC SWITCH
GATE VALVE
EMERGENCY HAND SWITCH
AIR PUMP
COMBINED AIR CHAMBER AND CHECK VALVE
RELIEF VALVE
Basement
Delivery Pipe Laid Below Frost.
Pump House
Electric Switch Should Always Be Connected To Tank In Basement.
Deep Well Pumps Can Be Procured That Are Driven By Air-Cooled Vertical Gasolene Engines. Ignition. By Magneto Or Battery And Will Stop Automatically

Fig. 34.—Deep well pneumatic water system with tank in house.

and also a very low power motor one-sixth to one-eighth H.P. for shallow wells and one-quarter for deep wells (100 to 200 ft.) is all that is necessary as a rule.

6. They are small, and compactly built, and therefore take up very little space in the building.

SELECTING A WATER SYSTEM.

In the selection of a water system for the farm plant, there are a number of points that should be considered carefully, chief of which are:—

1. *Capacity.*—If system is used for house only and is electrically operated, the pump should have a capacity of at least three gallons per minute for the average-sized house. If used also for stables, lawn service, etc., a much larger size is necessary, probably ten gallons per minute. It is wisdom to select a system too large than too small, as extra capacity and power is often greatly appreciated. Tank capacities, as mentioned on page 40, will also vary with kind of system used and the water consumption.

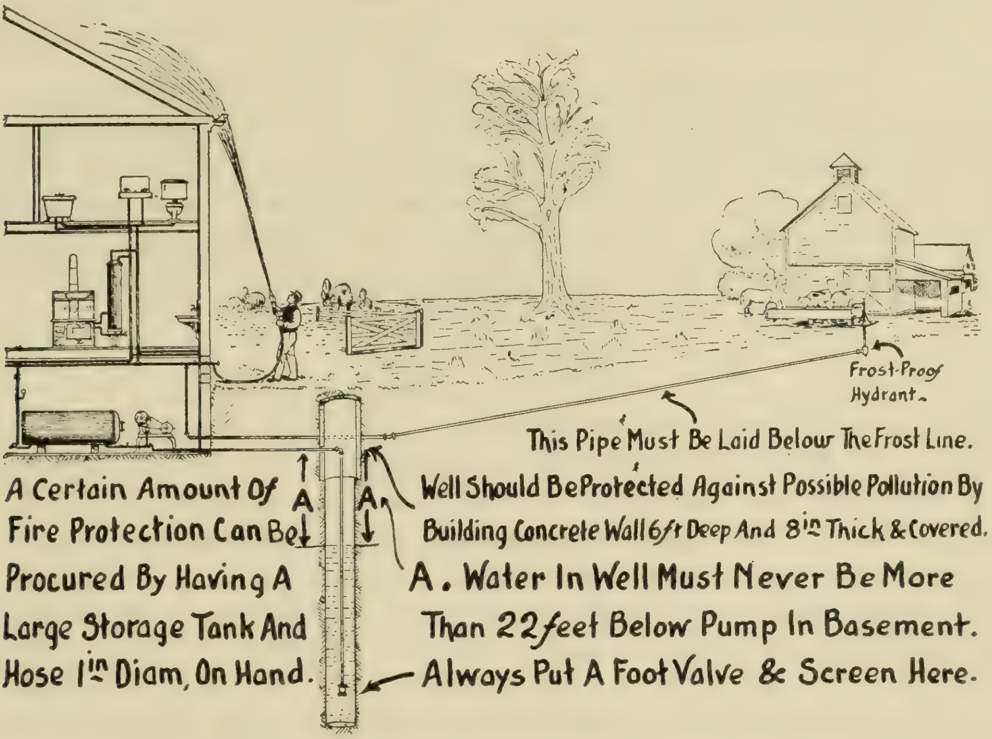

Frost-Proof Hydrant.
This Pipe Must Be Laid Below The Frost Line.
A Certain Amount Of Fire Protection Can Be Procured By Having A Large Storage Tank And Hose 1in Diam, On Hand.
A
A
Well Should Be Protected Against Possible Pollution By Building Concrete Wall 6ft Deep And 8in Thick & Covered.
A. Water In Well Must Never Be More Than 22feet Below Pump In Basement.
Always Put A Foot Valve & Screen Here.

Fig. 35.—Water under pressure for house and barn.

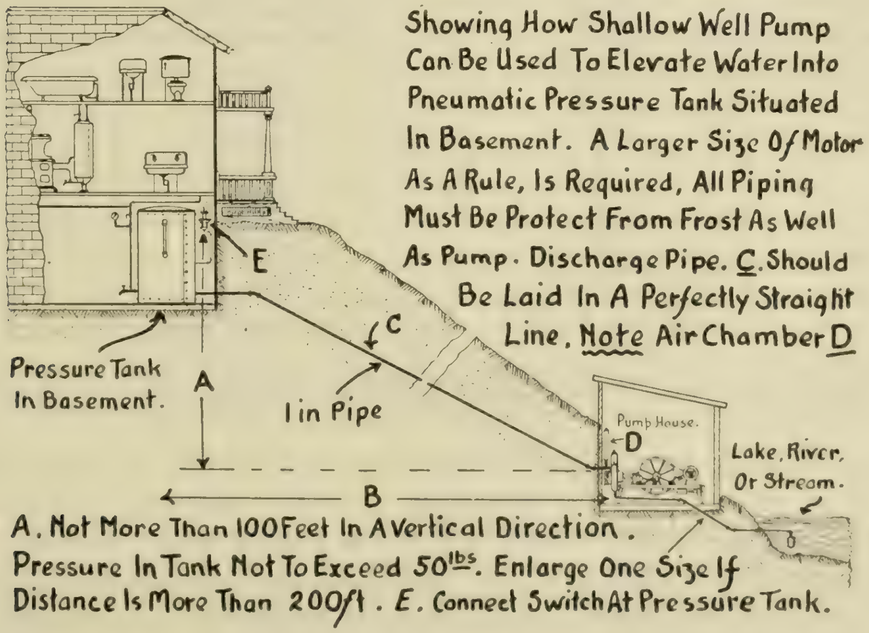

Showing How Shallow Well Pump Can Be Used To Elevate Water Into Pneumatic Pressure Tank Situated In Basement. A Larger Size Of Motor As A Rule, Is Required, All Piping Must Be Protect From Frost As Well As Pump. Discharge Pipe. C. Should Be Laid In A Perfectly Straight Line. Note Air Chamber D
E
C
Pressure Tank In Basement.
A
1 in Pipe
Pump House.
D
Lake, River, Or Stream.
B
A. Not More Than 100Feet In A Vertical Direction.
Pressure In Tank Not To Exceed 50lbs. Enlarge One Size If Distance Is More Than 200ft. E. Connect Switch At Pressure Tank.

Fig. 36.

2. *Kind of well, whether shallow or deep.*—If water at source is not more than twenty-two feet lower vertically than probable location of pump, a shallow well pump and installation is required, if more than this a deep well one must be chosen. In the former case the pump and other equipment may be located to one side of the well, preferably in the house basement. If the latter, then pump must be placed directly over the well and the cylinder placed close to or in the water. There is a great difference in the design, construction, method of installation and cost of these two installations.

3. *Power available for operating pump.*—The style and size of pump and storage tank will vary considerably with the means of operation, for instance if electric motor is used for running the pump, a much smaller and more compact pump can be used than if a gasoline engine or windmill is the source of power. It is the automatic of the electric unit feature that makes the difference.

4. *Make of system.*—There are many good ones on the market, and if one purchases an outfit from any reliable firm which has a good reputation in the designing and manufacturing of pumps and water systems, he may feel assured of satisfactory results. Plumbers, hardware merchants and farm machinery agencies handle the various types and are always glad to give demonstrations and any information they may have about the systems. (See Fig. 39.)

PRESSURE TANKS.

In case of compression water systems, these tanks contain both water and compressed air. They are well made and subjected to a factory test of 125-150 lbs. per sq. inch and are considered safe for a working pressure of at least 85 lbs., which is considerably above the pressure used in domestic water systems. They are tapped for both vertical and horizontal position, as seen in Fig. 32. There is a great range of size, but for farm purposes the few sizes given in the table below are quite adequate for all cases.

COMMON SIZES OF COMPRESSION TANKS FOR FARM SERVICE.

Diameter in inches.	Length in feet.	Full Capacity Imperial Gals.	Working Capacity ⅔ full.
13	1½	11	7
12	2½	15	10
16	4	42	28
18	4	53	35
18	5	66	44
24	4	100	66
24	5	120	90
30	6	220	146
36	6	315	210

To express capacities in Imperial gallons, multiply U.S.A. values by five-sixths.

The size of tank used depends on such conditions as space available for system, kind of power used for pumping, and the amount of water used. In ordinary suburban homes probably 40 to 80-gallon tank, whereas on farms a size varying from 80 to 120 for house, and if a large dairy is kept the size should be from 220 to 315 gallons or larger. Schools and other institutions will require a 525 gallon or larger tank.

The tanks should be kept in a frost-proof place, a bright, dry and comfortable basement being preferable.

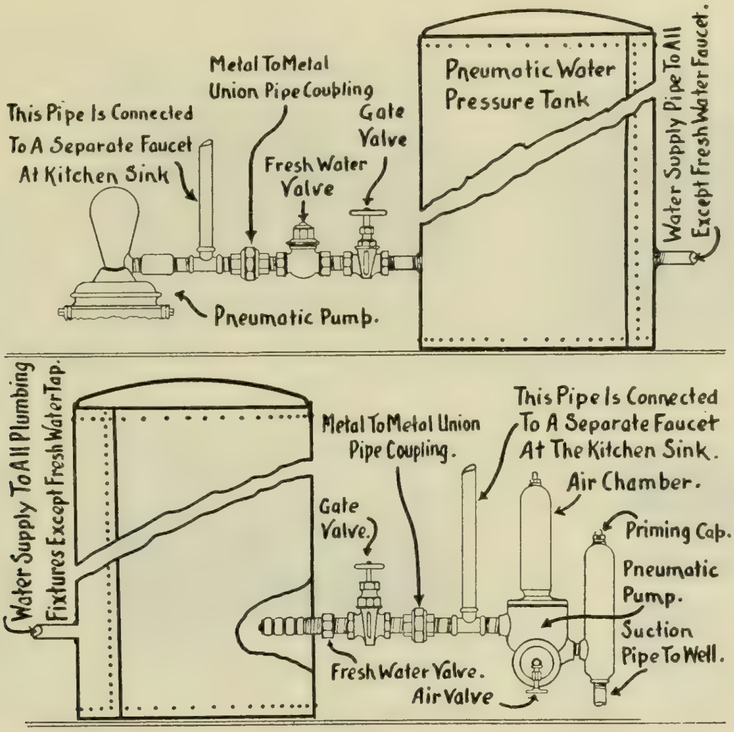

Metal To Metal Union Pipe Coupling
This Pipe Is Connected To A Separate Faucet At Kitchen Sink
Gate Valve
Fresh Water Valve
Pneumatic Water Pressure Tank
Water Supply Pipe To All Except Fresh Water Faucet.
Pneumatic Pump.
Water Supply To All Plumbing Fixtures Except Fresh Water Tap.
Metal To Metal Union Pipe Coupling.
This Pipe Is Connected To A Separate Faucet At The Kitchen Sink.
Air Chamber.
Gate Valve.
Priming Cap.
Pneumatic Pump.
Suction Pipe To Well.
Fresh Water Valve.
Air Valve

Fig. 37.—Fresh water from the well. How tanks are piped.

PRESSURE.

The pressure of the atmosphere at sea-level is approximately 15 lbs. per square inch. This is commonly known as one atmosphere. This pressure will sustain a column of mercury thirty inches long or a column of water thirty-four feet, water being 13.6 times lighter than mercury. It follows then that a depth of about two and one-third feet of water will be equivalent to one pound pressure. Therefore, to convert the gauge pressure as recorded on the pressure tank into terms of elevation, multiply pressure reading by two and one-third, or vice versa, divide a given elevation by two and one-third to get equivalent pressure in pounds. Take an example,—A pressure tank recording a pressure of forty pounds on the gauge and an open tank elevated 40 x 2⅓=93 feet will give approximately the same service. There is no doubt as to which is the better arrangement taking everything into consideration.

For ordinary service a pressure between twenty to fifty pounds is quite satisfactory, and these limits are maintained by the automatic switch in the circuit. It is not advisable for anyone to alter the switch once it is set in the factory and sent out with an outfit.

Water under good pressure is a great convenience in many respects; washing windows and cars, spraying lawns, cleaning out pens and stables or maybe fighting fire.

THE FUNCTION AND IMPORTANCE OF THE AIR-VALVE.

Every pump operating on a compression tank must be supplied with an air-valve on its cylinder for the purpose of keeping up the air supply to standard in the pressure tank. The air gradually leaks out of the tank with the water

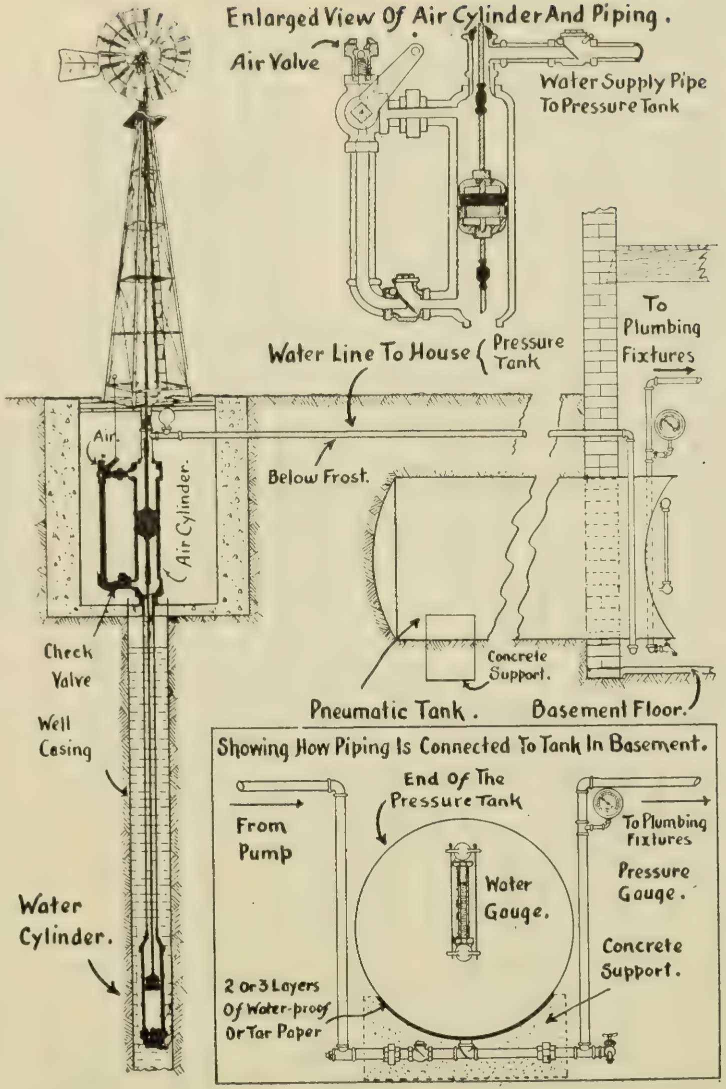


Fig 38.—Wind engine driven pneumatic water system.

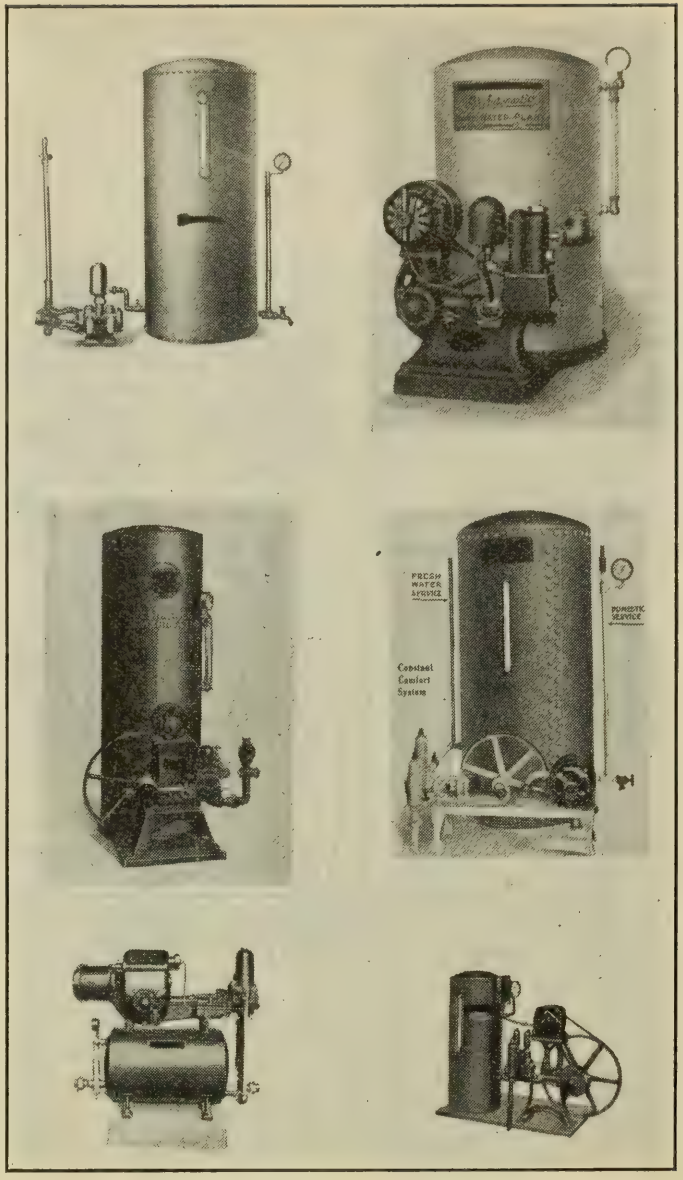


Fig. 39—Typical Automatic Water Systems

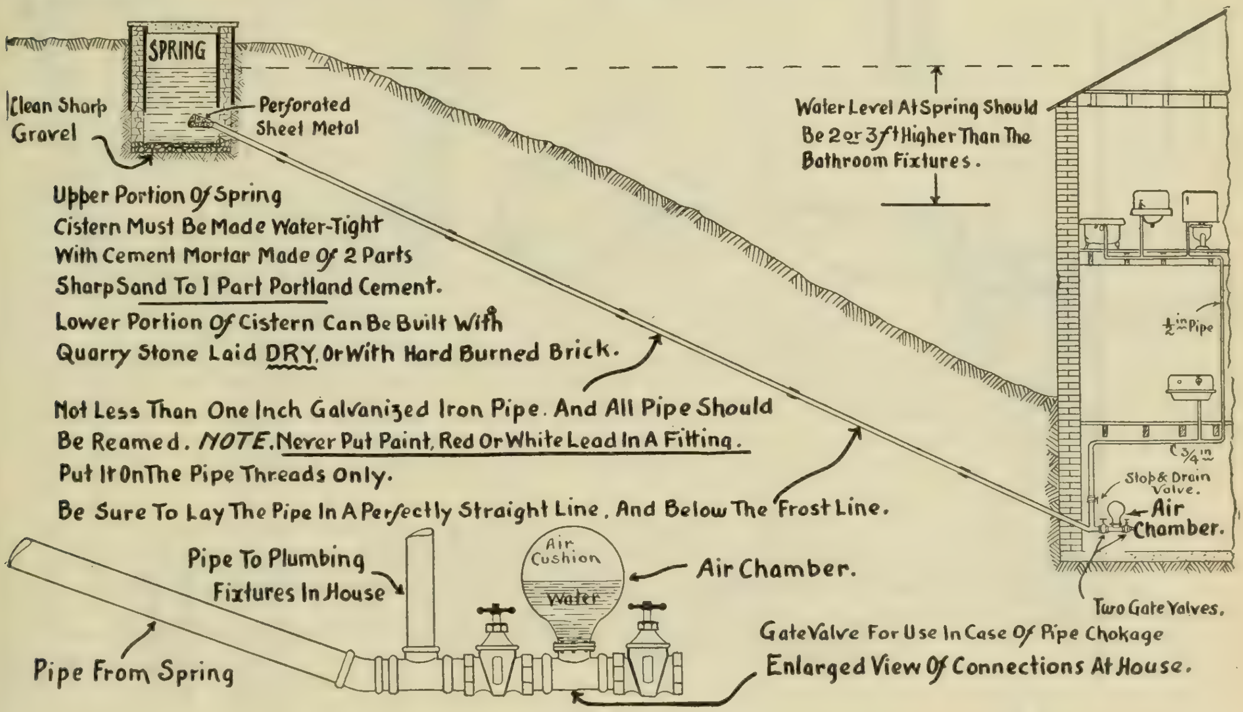
and if more air were not pumped in occasionally the tank would become waterlogged and useless as a pressure tank. Open the air-valve just often enough to keep the water in the tank on the water-line indicated about two-thirds way up on tank, and the pressure gauge at forty to forty-five pounds and all will be well with the pressure. The pressure gauge should be located close to the tank either on the tank itself or on discharge line and close to tank so that both gauges may be seen at the same time.

VARIOUS TYPES OF INSTALLATION.

Water systems are installed under quite a variety of conditions, and the most common ones are illustrated in Figs. 33 to 38.

These should be carefully studied by anyone intending to install a system of their own before any decision is reached regarding kind of equipment to order, etc. As considerable detail is given in these drawings and notes made under each one, no special elaboration is required at this point.

Compression systems may be operated by hand (Fig. 39), gasoline engine (Fig. 18), by windmill (Fig. 38), by electric motor (Figs. 33 and 34), or even by hydraulic ram though not recommended particularly.


SPRING
Clean Sharp Gravel
Perforated Sheet Metal
Water Level At Spring Should Be 2 or 3 ft Higher Than The Bathroom Fixtures.
½ in Pipe
¾ in
Stop & Drain Valve.
Air Chamber.
Two Gate Valves.
Pipe To Plumbing Fixtures In House
Air Cushion
Water
Air Chamber.
Pipe From Spring
Gate Valve For Use In Case Of Pipe Chokage
Enlarged View Of Connections At House.

Upper Portion Of Spring Cistern Must Be Made Water-Tight With Cement Mortar Made Of 2 Parts Sharp Sand To 1 Part Portland Cement.

Lower Portion Of Cistern Can Be Built With Quarry Stone Laid DRY, Or With Hard Burned Brick.

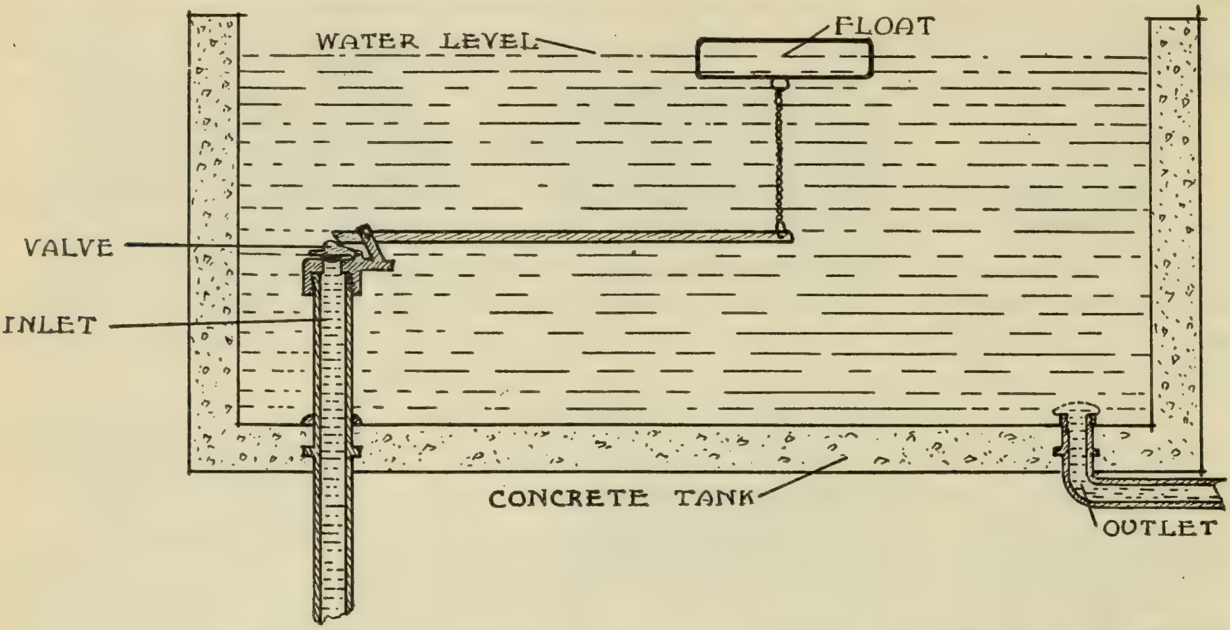
Not Less Than One Inch Galvanized Iron Pipe. And All Pipe Should Be Reamed. *NOTE.* Never Put Paint, Red Or White Lead In A Fitting. Put It On The Pipe Threads Only.

Be Sure To Lay The Pipe In A Perfectly Straight Line, And Below The Frost Line.

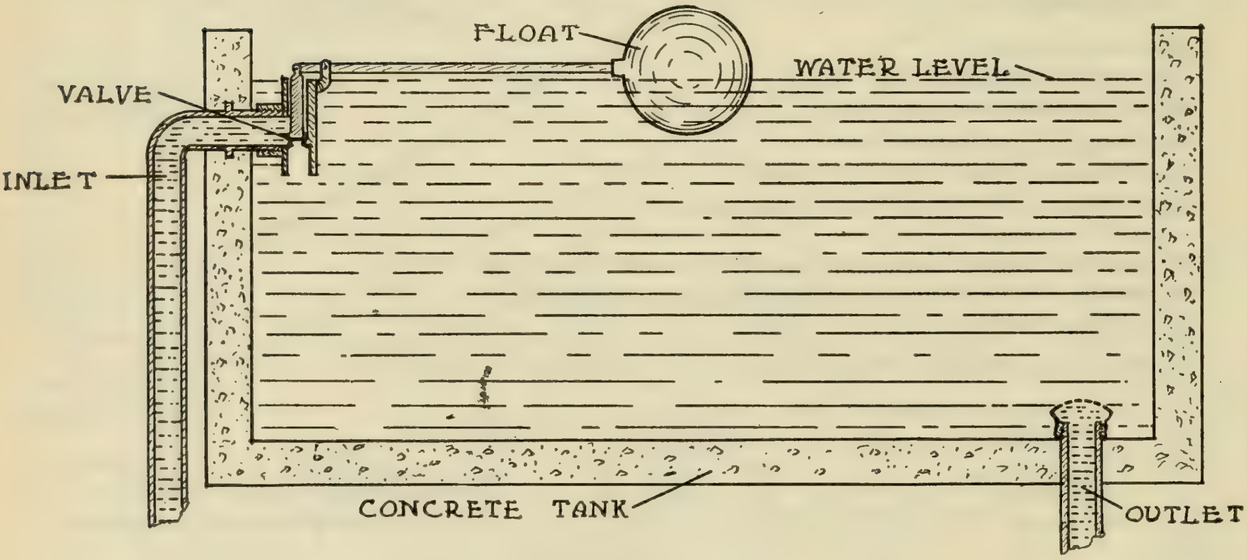
Fig. 40.—Spring Water Piped to the House

GRAVITY SUPPLY FROM SPRINGS, STREAMS AND LAKES.

Springs, streams and lakes are frequently the source of water supply for various purposes. If the point of use is lower down than the source then a pipe may be laid and the water allowed to flow down by gravity, care being taken that the pipes are placed deep enough underground to escape frost. In this plan, trouble is occasionally experienced, the water running for a time, but gradually stopping. Usually this is due to the lodgment of air somewhere in the pipe. This air comes from the water little by little. We have all seen a glass of cold water set in a warm room and later found the inside of the glass coated with innumerable small bubbles of air that had come out of the water as the temperature increased. Under certain conditions the same thing occurs in the water pipes, and by and by numbers of these small bubbles joining together form larger bubbles, and because of their lightness the large air bubbles try to flow back up the pipe toward the source. When they grow large enough and sufficient in number, the back pressure may entirely stop the water. And if there are any irregularities in grade the air tends to collect in the high spots from both directions. The slower the grade or the smaller the pipe the greater the danger from this source, because then the velocity of the water in the pipe is not sufficient to brush off the small bubbles and carry them along toward the outlet. If the trouble occurs in a pipe on a uniform grade it may be relieved by tapping standpipes into the waterline at intervals, or an an uneven grade, at the high spots. Generally it is not wise to use smaller than inch pipe for gravity systems. The end of the pipe in the source must be provided with a screen to keep back small stones, sticks or anything that might tend to choke the pipe line. The line should be laid as straight as possible, the joints in it well leaded and screwed up close so as to cover all the threaded portions of the pipes. This system is quite rare because very few places have the source of water supply high enough to make its adoption practicable. Fig. 40 shows details of such system.



Type A.



Type B.

Fig. 41.—Regulating tank, showing details and valves of different types.

WATER SYSTEMS FOR THE FARM STABLES.

By this time farmers are fully aware of the value of a wholesome supply of water for their livestock. It is a fact that dairy cattle will produce more milk if they get all the pure water they need, and all classes of animals will be healthier if they have plenty of pure water to drink.

It is important to have a good method of supplying the water. It will insure a constant supply for the stock at all times and save much time and labour at chore time.

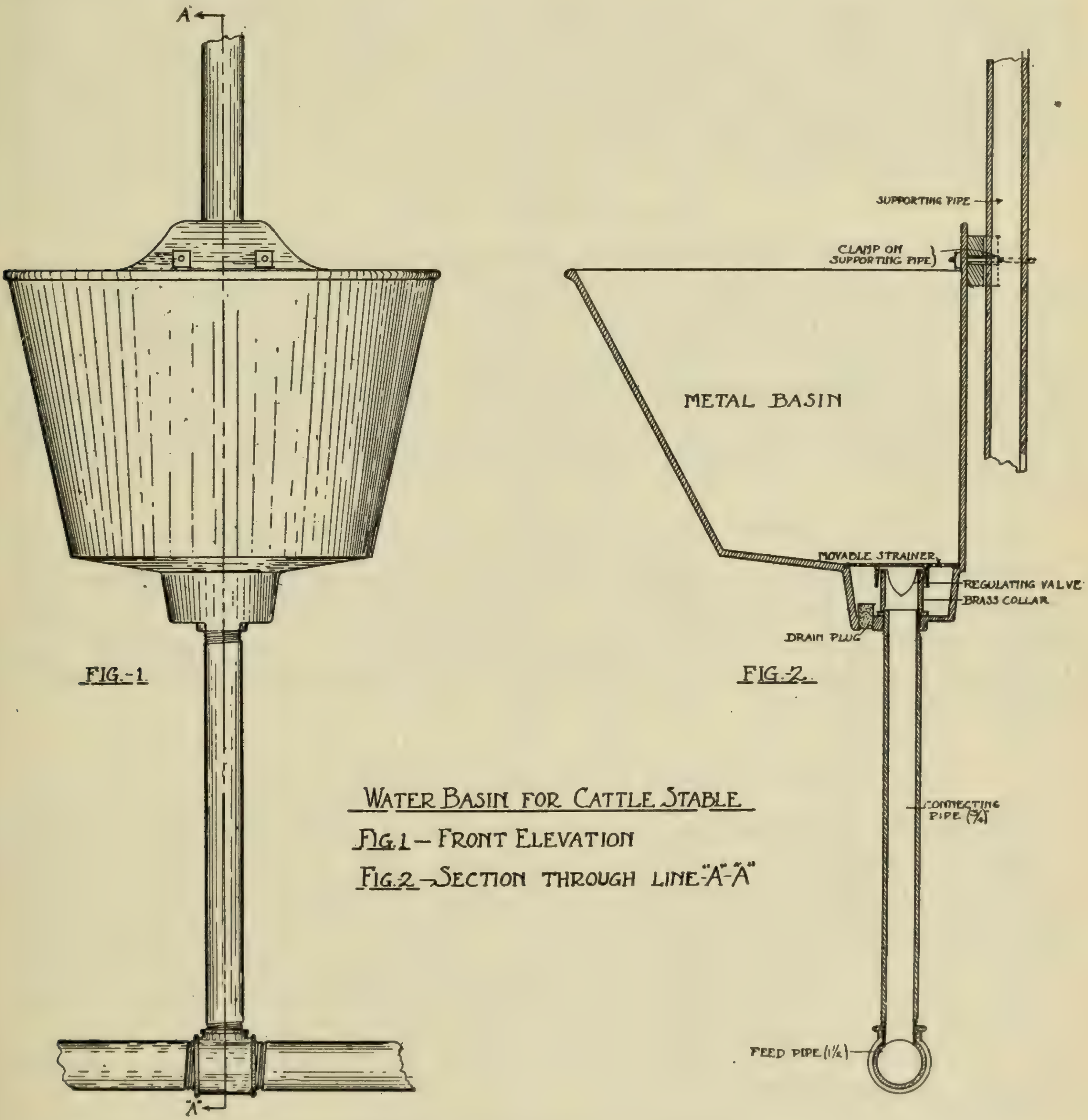


Fig. 42—Water basin for stable.

FEATURES OF A GOOD SYSTEM.

A water system for the stable should be simple in construction, easily kept clean and sanitary, not subject to clogging or getting out of order, reasonably cheap and reliable and not requiring much attention.

As to systems of supply, all agree that the water should be supplied in some manner at the mangers so that the cattle need not be let out-of-doors to get a drink. The following are different ways of doing this.

THE INDIVIDUAL BASIN SYSTEM.

The most common method in our best stables is by means of individual drinking basins connected up to a regulating basin supplied with water from a storage tank at the ceiling or in the hayloft. See Fig. 22.

THE COMMON TROUGH SYSTEM.

Another system consists of a common watering trough in front of the cattle, the water being let in as required by a faucet at one end of the trough, and drained by a plug at the lower end when cleaning out is necessary. The trough is made of metal and is placed about three feet above the floor and right against the manger side of the stanchions. This position does not interfere with the cattle when eating out of the mangers, or when standing at ease. This system is best adapted to the fixed type of manger.

THE MANGER SYSTEM.

Still another system is that of using the feed manger as the watering trough. In this case the water supply is piped to the higher end of the manger and let in by a faucet, the drain plug being at the other end. After the feeding is over, both night and morning, the mangers are thoroughly cleaned out and the water let in and left until the cattle have had their fill. Both of these last two systems, just described, have been in use at the College stables for some time, the former in the beef stable, the latter in the dairy. The herdsmen find them very satisfactory.

THE COMPRESSION SYSTEM FOR HOUSE AND BARN.

Since the introduction of the compression water system for homes, many farm stables are being supplied with water under pressure from a common pressure tank for both house and barn. See Fig. 22. In such installations a frost-proof hydrant is put in the lawn or at some convenient point outside, as shown in the illustration.

THE WINDMILL OPERATING A DUAL SYSTEM.

The reader is referred at this point to Fig. 21, illustrating the use of the windmill for pumping water into a compression tank in the basement of the house for domestic use, and into an open tank in the barn for serving the stable with water. In this case the operation is automatic, the wheel being pulled into the wind when pressure goes down to about twenty pounds, and out when it rises to forty. Farmers with good windmills in use now for pumping water into the stables or maybe only into troughs in the yard might be interested to know that they can have water service in the house also by installing a pressure tank and some accessories.

THE HYDRAULIC RAM PUMPING WATER FOR HOUSE AND BARN.

In Fig. 25 is illustrated how the barn storage may be kept supplied by hydraulic ram. If hydraulic ram is used for supplying barn only the over-head tank may be done away with and the water allowed to flow constantly through a trough in front of the cattle. This makes a very simple, cheap and sanitary system.

WATER TANKS.

There are various styles of tanks for this purpose,—wood, steel and concrete made up in round, oval, square and rectangular forms. In some instances the concrete construction is preferable, but to-day a good many steel tanks are being installed. The round end steel form may be strapped to the ceiling of the stable if desired, the other types are more adapted for placing in the hayloft. The size depends on amount of stock kept and the type of water system used. If windmill is used for pumping, the tank should be large enough to hold about one week's supply of water, in order to have plenty during calm days. A tank six by five by five feet will hold enough to supply forty head of stock about three days. The same is true to some extent for pumping water by gasoline engine. However, if automatic pumps are used, there is no reason for a large tank except to provide against lack of water during a breakdown. Water tanks need some protection against frost when located outside or above the stable itself.

WATER TANKS—SIZES AND CAPACITIES.

Style of Tank.	Dimensions.			Capacity.
	Diameter.	Height.	Length.	
Round Steel Tanks	4 ft.	4 ft.	....	297
	4 ft.	5 ft.	....	372
	5 ft.	5 ft.	....	587
	5 ft.	6 ft.	....	695
Round End Steel Tanks	2 ft.	2 ft.	4 ft.	78
	2 ft.	2 ft.	6 ft.	122
	2½ ft.	2 ft.	8 ft.	206
	3 ft.	2 ft.	10 ft.	317
Round Wood Tanks	4 ft. (bottom)	....	4 ft.	285
	4 ft.	....	5 ft.	360
	5 ft.	....	5 ft.	570
	5 ft.	....	6 ft.	675
	Length.	Width.	Depth.	
Square and Rectangular Tanks	5 ft.	4 ft.	3 ft.	375
	4 ft.	4 ft.	4 ft.	400
	6 ft.	4 ft.	4 ft.	600
	6 ft.	5 ft.	4 ft.	750
	6 ft.	5 ft.	5 ft.	937

NOTE.—1 cubic foot=6¼ Imperial gallons, or 7½ U.S.A. gallons.

REGULATING VALVES FOR OPEN TANKS.

When open tanks are filled by automatically controlled pumps, it is necessary to equip the tanks with a good pressure float valve, as illustrated in two different types of installations in Fig. 41 (*a*) and (*b*).

WATER BASINS.

One prominent feature of present-day stable equipment is automatic water supply through water basins placed in front of the stock. There are different styles of basins, in some the water level is controlled by a regulating tank connected up with the basins, and there is only a very simple check valve in the bottom of basin, in others there is a spring valve in basin and animal gets supply by pressing its nose on a disc that opens the valve. Again some basins are single, others double. One type of basin, a very simple one, is shown in Fig. 42. If these basins are given the required attention to keep them clean and sanitary, and the vital parts kept in good working order, they will be found on the whole to be satisfactory for farm stables. Some are easily taken part for purposes of cleaning.

PLUMBING

When one is going about to install a complete plumbing system in his home, there are a few general principles that he should consider carefully before he proceeds with the work.

Selecting the Bathroom.

In a two-storey house the bathroom should be directly, or as near as possible, above the kitchen, and if there is a laundry room in the basement it should be directly below the kitchen again. This arrangement provides for the simplest, most compact, cheapest and most efficient system. If possible, the whole system should be next to the warmest side of the house, the south preferably, as it will be less liable to freeze, the rooms will get more sun and be more sanitary, and besides, the septic tank to which the system leads should be on the warmest side if possible. The bathroom should have at least one good window facing the morning sun and fitted for convenient ventilation. In summer the window should have a good sized screen. The size need not be large, about sixty square feet, the exact dimensions depending on how the fixtures are arranged in the room, where the window and door are located, also position of the stack. If all three fixtures are placed along one side and a five-foot bathtub is used, it will required a room 9′ x 6′. If bathtub (5½′ in length) and the closet bowl and tank are placed along one wall and the lavatory or washbasin on the opposite side or at one end, the size will need to be about 8½′ x 7′. See Figs. 43 and 44 for suggestions in laying out bathrooms. The closet should be close as possible to the stack and the nearer the other fixtures are to the stack the better the layout. In one-storey houses, or in any case where bathroom is on the same floor as the kitchen, the two rooms should be as near to each other as convenient.

The General Layout and Principle of a Plumbing System.

As will be seen by examining Figs. 44, 45 and 46, a plumbing system consists of the four-inch cast-iron stack extending from the basement to a point about two feet beyond the roof, and always ten feet away from dormer window, waste pipes and traps connecting the various fixtures to the stack, hot and cold water pipes, one thirty-gallon range boiler for hot water and the bathroom, kitchen and laundry fixtures. Its function is to supply the house with pure running water, hot and cold, and to remove all waste matter from the sinks and other fixtures and dispose of them in a sanitary manner in the sewer or septic tank as the case may be.

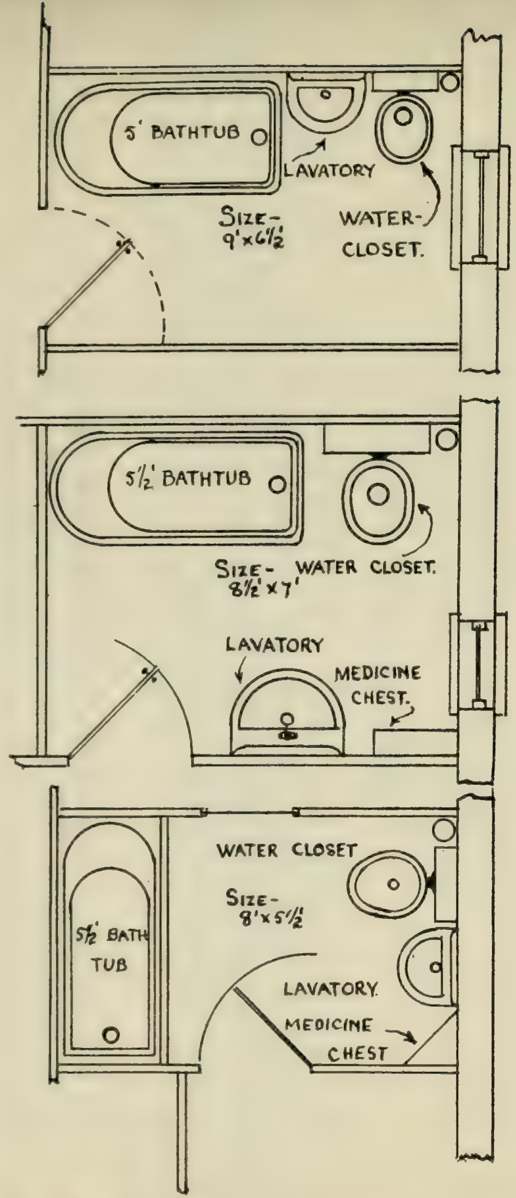


Fig. 43.—Suggested Lay-outs of Bathrooms

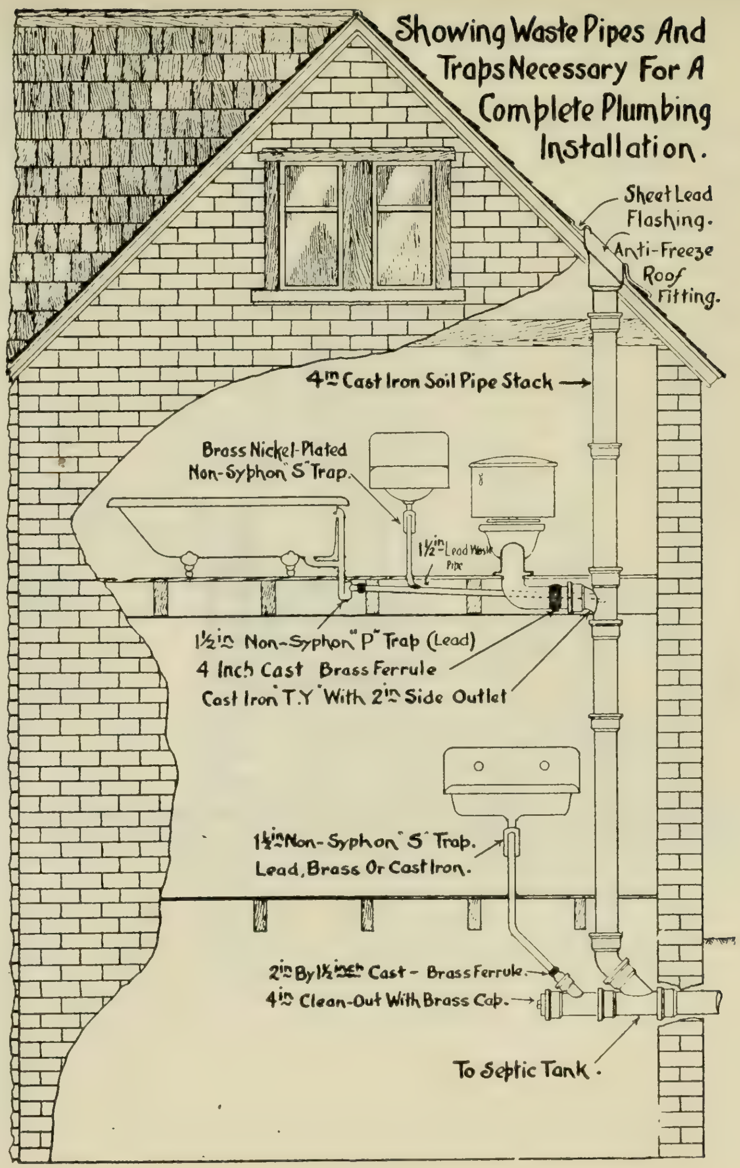

Showing Waste Pipes And Traps Necessary For A Complete Plumbing Installation.
Sheet Lead Flashing.
Anti-Freeze Roof Fitting.
4in Cast Iron Soil Pipe Stack
Brass Nickel-Plated Non-Syphon "S" Trap.
1½in Lead Waste Pipe
1½in Non-Syphon "P" Trap (Lead)
4 Inch Cast Brass Ferrule
Cast Iron "T.Y" With 2in Side Outlet
1½in Non-Syphon "S" Trap. Lead, Brass Or Cast Iron.
2in By 1½inch Cast - Brass Ferrule.
4in Clean-Out With Brass Cap.
To Septic Tank.

Fig. 44.

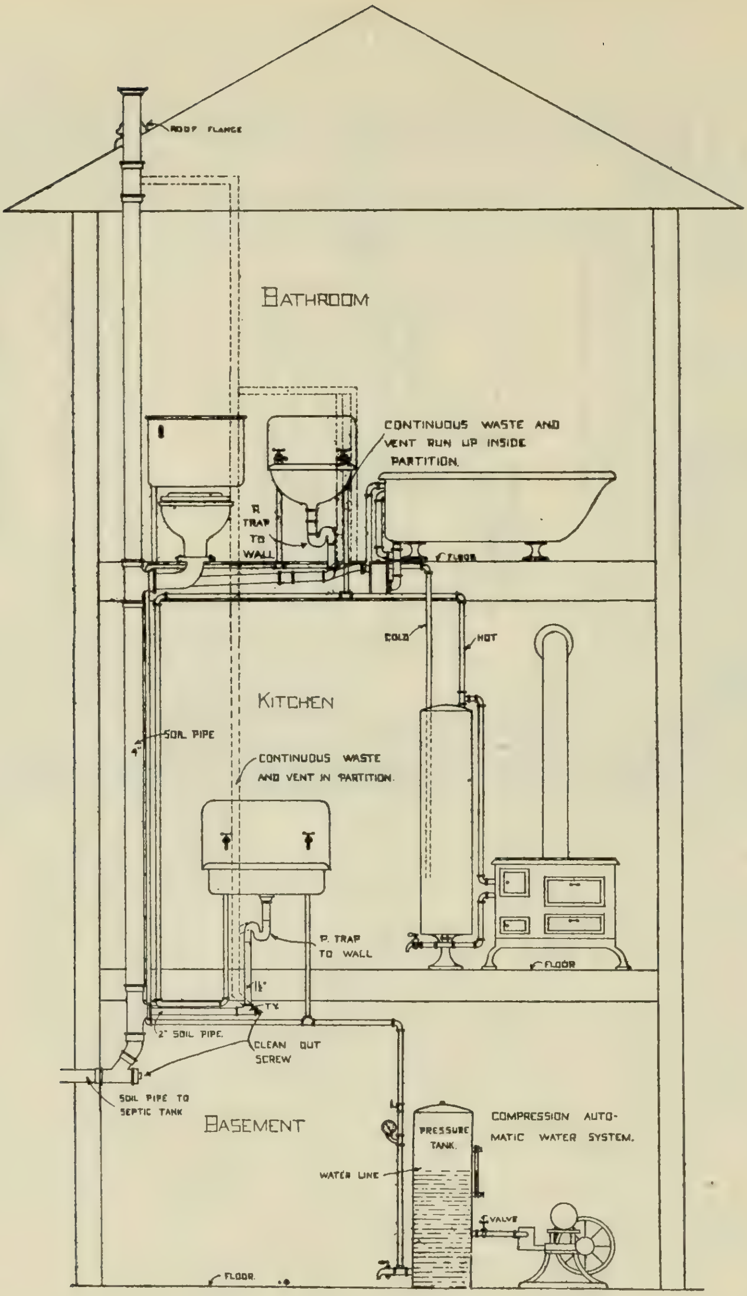


Fig. 45.—A Complete Plumbing System

"Roughing-in" Material.

This consists of soil pipe, water pipe, lead pipe, traps and pipe fittings and connections necessary to join up the different parts into one system. The plumber's first job, after laying the system, is to assemble all this material, and this he describes by the term "roughing-in." Afterwards the work is completed by connecting up the fixtures to the waste pipes, and the water service to the faucets.

All the material that is used for plumbing should be of standard quality and good in every respect. The quantity required and the cost for any job cannot be stated definitely except by an experienced mechanic, after he has made a careful estimate. The following information, however, may be useful in this respect to anyone who wishes to acquaint himself as to nature, and approximate amount of material needed for an ordinary dwelling.

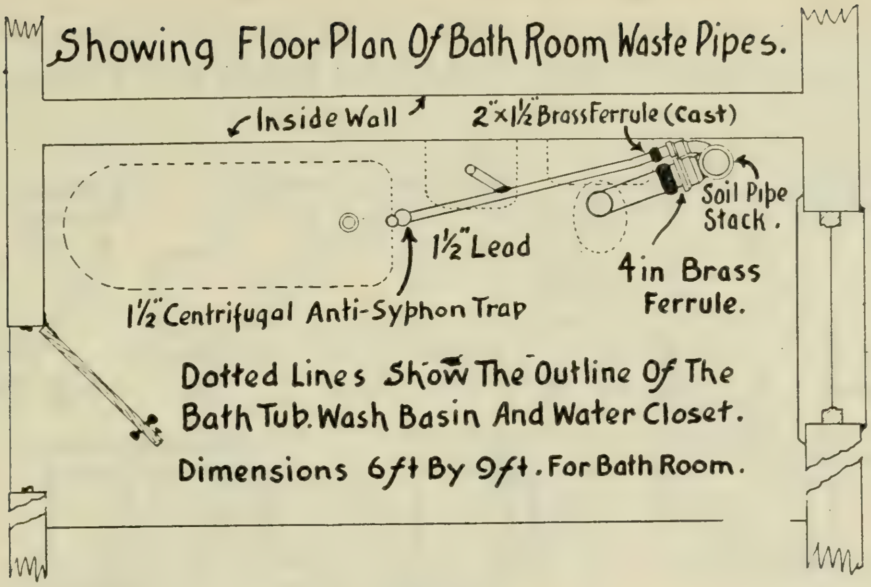

Showing Floor Plan Of Bath Room Waste Pipes.
Inside Wall
2"×1½ Brass Ferrule (Cast)
Soil Pipe Stack.
1½" Lead
4 in Brass Ferrule.
1½" Centrifugal Anti-Syphon Trap
Dotted Lines Show The Outline Of The Bath Tub. Wash Basin And Water Closet.
Dimensions 6ft By 9ft. For Bath Room.

Fig. 46.

CAST-IRON SOIL PIPE.

The quality of soil pipe used for dwellings is designated medium weight, or 45 lbs. per 5-ft. length. It is made in five-foot lengths, either single or double hub, and in various diameters, but for ordinary jobs only two sizes are used: four-inch for stack and two-inch for waste pipes and vents. It takes about forty feet of four-inch for the stack and run to septic tank close to house, and a quantity of two-inch, hard to estimate for waste pipes, probably ten to fifteen feet. In ordering pipe for stack it is economy and a convenience to order a couple of double hub lengths.

LEAD PIPE.

The standard lead pipe used for branch soil waste, vent or flush pipes shall not weigh less than 8 lbs. per lineal yard for 1½-inch, the common size. It is the best material and most commonly used for waste pipes from the bathtub and lavatory. Galvanized wrought-iron and cast-iron soil pipe may be used with very good results and is cheaper and easier to install. The amount of waste pipe varies considerably, amounting to probably eight to ten feet. A brass ferrule is always used to join the lead waste pipes to the stack.

GALVANIZED IRON PIPE.

For the ordinary job it requires about 150 feet of half-inch pipe to supply hot and cold water to all fixtures, and a small quantity of three-quarter-inch between range boiler and coil in furnace or waterfront in kitchen range, the amount depending on distance between boiler and furnace.

WATER PIPE GALVANIZED FITTINGS.

(Note Fig. 49.)

The following statement is an approximation of the water pipe fittings needed for an ordinary house job: 3 dozen ½-inch elbows, 2 dozen ½-inch nipples (assorted), 1 dozen ½-inch tees, 2 or 3 ½-inch unions, 2 or 3 ¾-inch unions, 2 boiler unions, 4 1 x ¾-inch elbows, 1 ½-inch drain faucet for boiler (brass), 1 ½-inch shut-off for range boiler (brass), 6 to 8 ¾-inch elbows for boiler connections, ½ dozen ¾-inch nipples, and 4 or 5 feet of 1-inch pipe and a return bend for coil in furnace, 2 or 3 stop and waste cocks, one for main shut-off of water supply, the others for shut-off on lawn service pipes, 2 or 3 hose bibbs for lawn service.

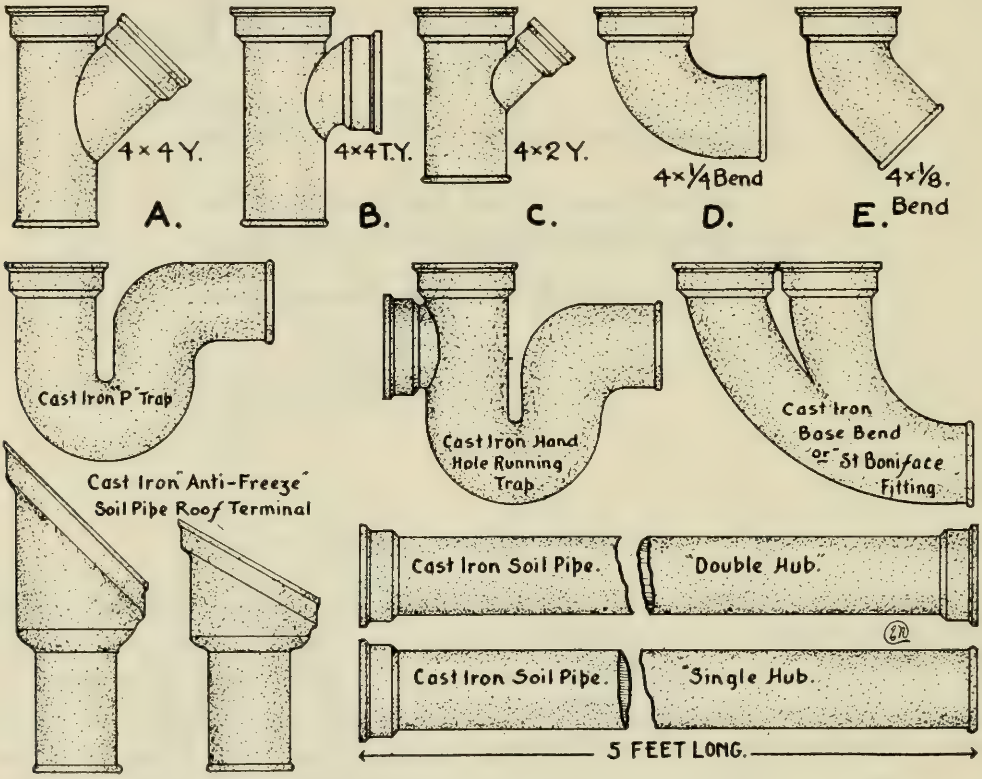


Fig. 47.—Cast iron soil pipe and fittings.

SOIL PIPE FITTINGS.

(See Fig. 47.)

¶ The following named cast-iron fittings are required for roughing-in plumbing system for house: one 4 x 4 x 2 special T-Y with either right or left side inlet. This one fitting provides for 4-inch opening for closet and the 2-inch opening for bath and basin. This is a very useful fitting and is highly recommended. One 4 x 2 T-Y or Y for connecting sink waste to stack; one 4-inch T-Y with clean-out screw for joining base of stack to horizontal pipe through cellar wall or instead one Y with ⅛ bend; one 4-inch lead bend with lead and iron or brass ferrule for joining closet bowl to special fitting. It may be had in 12 inches, 16 or 18-inch lengths as required. One or two 4-inch soil pipe bends to provide for angles in the soil pipe if necessary; one or two 2-inch soil pipe bends in case of altering direction of waste pipe for kitchen drain, etc.; one 4-inch offset may be needed in case any bend is necessary in the stack; one roof flashing for securing water-tight joint between stack and roof of any approved design, the Bullard type being adjustable to any pitch of roof; 10 lbs. of oakum and about 50 lbs. of caulking lead for soi pipe joints, and about 10 lbs. of wiping solder for wiped joints.

TRAPS.

Traps or water seals serve a very important part in a plumbing system in preventing the return of sewer gas or abnoxious odours into the house by way of the waste pipes and fixtures. Every fixture should have a separate trap with a water seal not less than two inches. Traps should be placed as close as possible to the outlets of the fixtures and never more than twelve inches away. There are many different styles of traps. Fig. 48 illustrates the most common types. Traps (*a*), (*b*) and (*c*) are particularly suitable for kitchen sink and laundry tubs, (*c*) and (*d*) for washbasin in bathroom and (*e*) and (*f*) for bathtubs or (*b*) if vented and (*c*) in "P" trap. Nickel plated centrifugal anti-siphon traps are always used on lavatory in bathroom on the best jobs and often in the kitchen as well. The anti-siphon or the more expensive ones are recommended highly because they are less liable to lose their water seal and therefore are more sanitary and efficient.

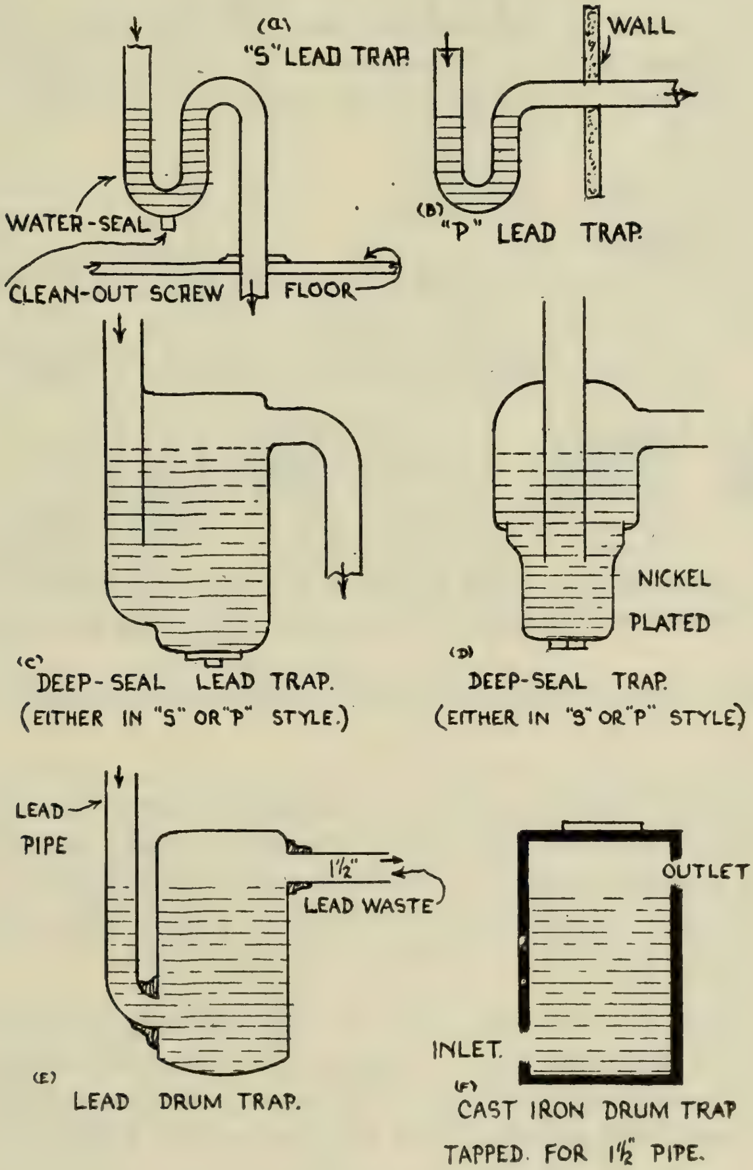


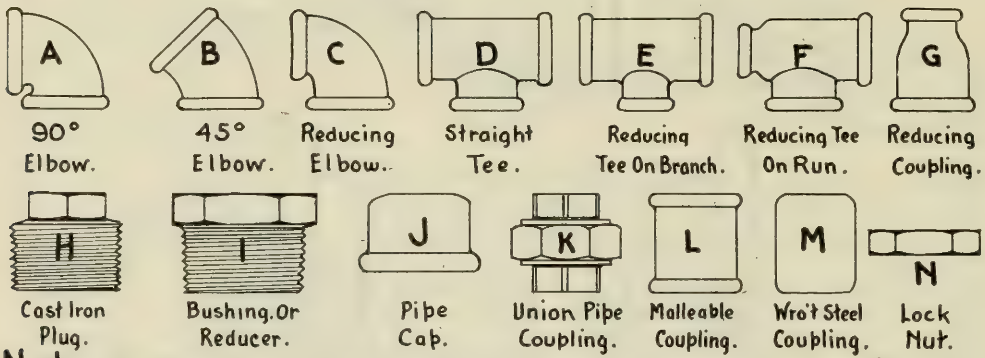
Fig. 48.—Common Styles of Traps

VENTING.

Venting consists of giving all waste pipes a clear circulation of air and thereby preventing any possibility of siphoning of the traps. It is required by regulation in most of the cities to-day but not in the country. See Fig. 45 for layout of the venting in a plumbing system.

FIXTURES.

In regard to the plumbing fixtures for bathrooms and kitchens, there are designs and prices to suit all tastes and purses. In putting in a permanent system of plumbing it is a wise policy to select something pretty good as it is likely to be in style for a long time, it will give good wear, be sanitary and have a good appearance. Built-in bathtubs, pedestal basins, tiled floors, etc., are inviting and they certainly are very sanitary and efficient. From the utility standpoint, the quality and wearing ability of the surfaces of the fixtures is the essential thing. The best fixtures are made of cast-iron body with high quality enamel finish, the cheaper ones of sheet metal and enamel finish.



Note. *Fittings A.B.C.D.E.F.&H. Can Be Had In Cast Iron. Above Are All Made Of Malleable Iron, Except H. Cast Iron Pipe Fitting Have Square Beads (As A Rule).*

Fig. 49.—Popular pipe fittings used in plumbing and water systems.

Bathtubs.—The two common styles are the ordinary and the built-in. They are made in 4½, 5, 5½ and 6-foot lengths, the five-foot being the commonest size. The width is standard at 2½ feet including the rim of three inches. For a few dollars extra a simple shower head may be installed to bathtub.

Washbasins.—There are two main styles, those that hang on the wall and those supported by a pedestal. They vary in size and shape. The common dimensions of the former type are 17″ x 19″ (commonest size), 18″ x 20″, 20″ x 22″, 20″ x 24″. Some are square, others are oval, some are flat-back, others are corner basins. The pedestal ones are somewhat larger in dimensions and are built in different shapes.

The Water Closet.—There is some variation in the style and manufacture of the bowl and tank. The tank mechanism needs to be reliable in operation and well built, else considerable annoyance and repair will result. The tank occupies twenty-four inches on the wall, and the distance from wall to outer edge of seat is twenty-six to twenty-eight inches.

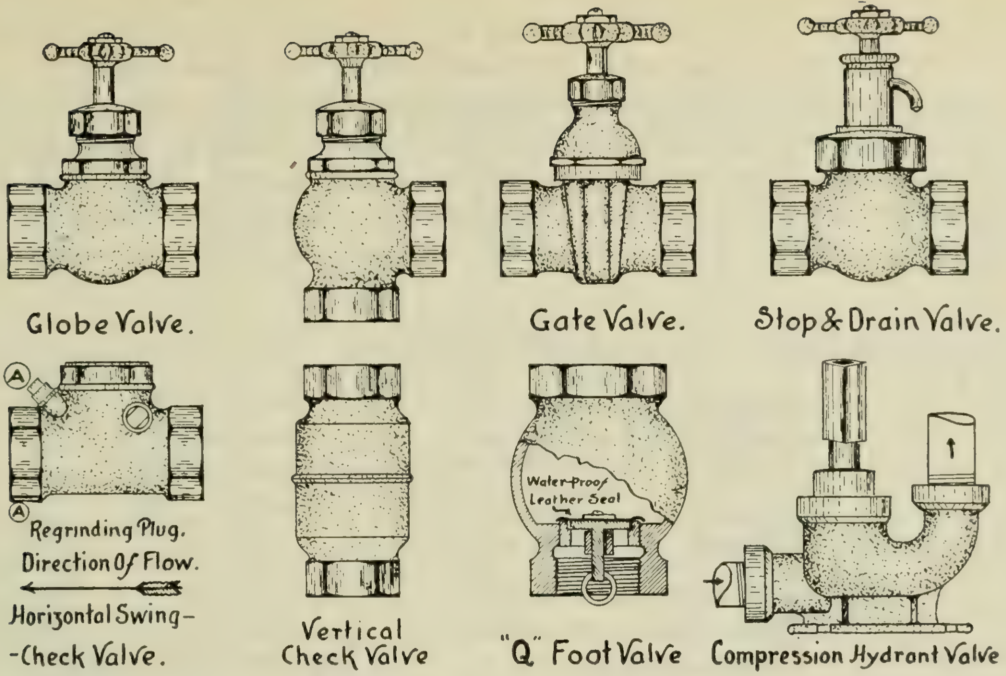


Fig. 50.—Globe, angle and gate valves, horizontal and vertical check valves, stop and drain valve, foot valve and compression hydrant valve.

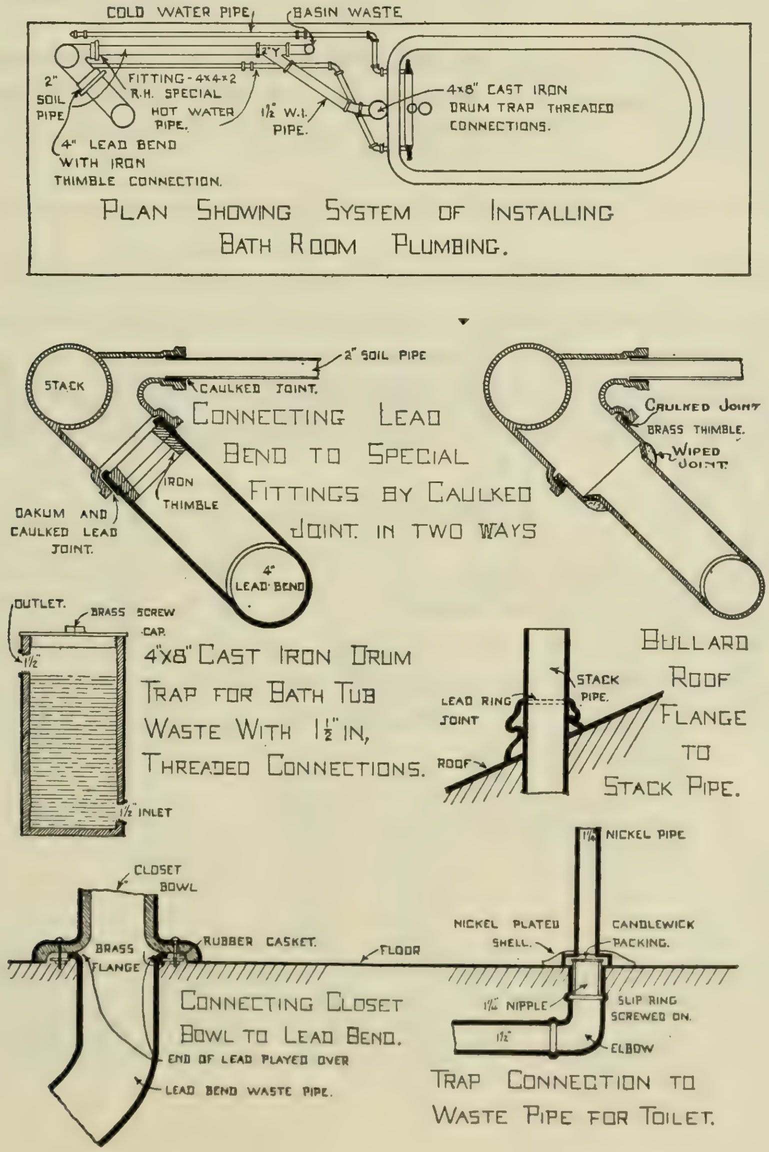

COLD WATER PIPE
BASIN WASTE
2" Y
2" SOIL PIPE
FITTING - 4×4×2 R.H. SPECIAL
HOT WATER PIPE.
1½" W.I. PIPE.
4×8" CAST IRON DRUM TRAP THREADED CONNECTIONS.
4" LEAD BEND WITH IRON THIMBLE CONNECTION.
PLAN SHOWING SYSTEM OF INSTALLING BATH ROOM PLUMBING.
STACK
2" SOIL PIPE
CAULKED JOINT.
CONNECTING LEAD BEND TO SPECIAL FITTINGS BY CAULKED JOINT. IN TWO WAYS
IRON THIMBLE
OAKUM AND CAULKED LEAD JOINT.
4" LEAD BEND
CAULKED JOINT
BRASS THIMBLE.
WIPED JOINT.
OUTLET.
BRASS SCREW CAP.
1½"
4"X8" CAST IRON DRUM TRAP FOR BATH TUB WASTE WITH 1½" IN, THREADED CONNECTIONS.
1½" INLET
STACK PIPE.
LEAD RING JOINT
ROOF
BULLARD ROOF FLANGE TO STACK PIPE.
1¼" NICKEL PIPE
CLOSET BOWL
BRASS FLANGE
RUBBER GASKET.
FLOOR
CONNECTING CLOSET BOWL TO LEAD BEND.
END OF LEAD PLAYED OVER
LEAD BEND WASTE PIPE.
NICKEL PLATED SHELL.
CANDLEWICK PACKING.
1¼" NIPPLE
SLIP RING SCREWED ON.
1½"
ELBOW
TRAP CONNECTION TO WASTE PIPE FOR TOILET.

Fig. 51.—Special Connections of a Plumbing System

The Kitchen Sink.—The kitchen sink gets a great deal of use, and therefore should be built to stand up well. It should have two drainboards if possible, either wood or metal; it should be high enough, about thirty-six inches off the floor, to avoid the woman stooping too much when using it; it should be in a bright, cheerful place and yet convenient to the stove and cupboards; the sink and the back should be in one piece to make it sanitary and easily kept clean. The common size is 18″ x 30″. For washing dishes it is a convenience to have the screen over the outlet provided with some sort of shutter or plug. The combination sink and laundry tub is a very good arrangement in case the kitchen is used for a laundry, the washtub section being covered up by a tap or drainboard when it is not required. This is the very type of fixture for the farm home, as it is not always possible to get drainage from a tub installed in the basement.

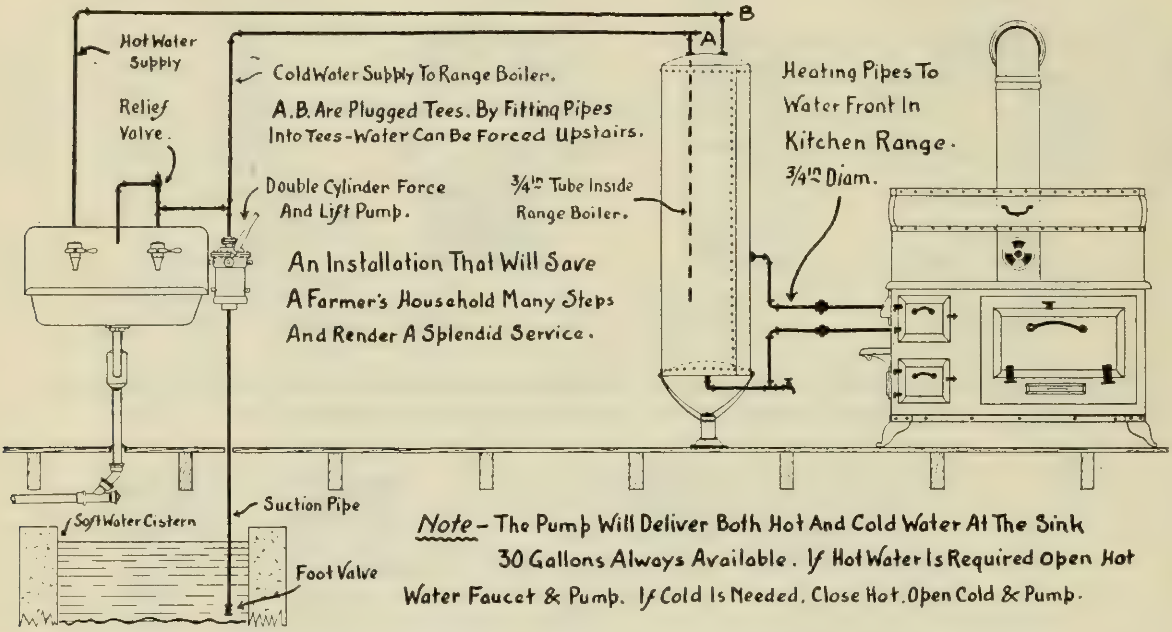

B
A
Hot Water Supply
Relief Valve.
Cold Water Supply To Range Boiler.
A.B. Are Plugged Tees. By Fitting Pipes Into Tees-Water Can Be Forced Upstairs.
Heating Pipes To Water Front In Kitchen Range. 3/4" Diam.
Double Cylinder Force And Lift Pump.
3/4" Tube Inside Range Boiler.
An Installation That Will Save A Farmer's Household Many Steps And Render A Splendid Service.
Suction Pipe
Soft Water Cistern
Foot Valve
Note - The Pump Will Deliver Both Hot And Cold Water At The Sink 30 Gallons Always Available. If Hot Water Is Required Open Hot Water Faucet & Pump. If Cold Is Needed, Close Hot. Open Cold & Pump.

Fig. 52.—A simple hot water system—cistern pump connected to kitchen range boiler.

PLUMBING TOOLS.

A set of plumbing tools is made up chiefly of the following items: 1 fire pot, 1 metal pot for lead, 4 inches in diameter with handle, 1 ladle for pouring lead into joints, 1 asbestos rope for use in pouring horizontal joints, 1 set of caulking irons, 4 different types, 2 pipe wrenches, 10″ and 14″ sizes, 1 pipe cutter, 1 stock and dies, ¼″ to 1¼″, 1 pipe vise. This set will cost about $40.00.

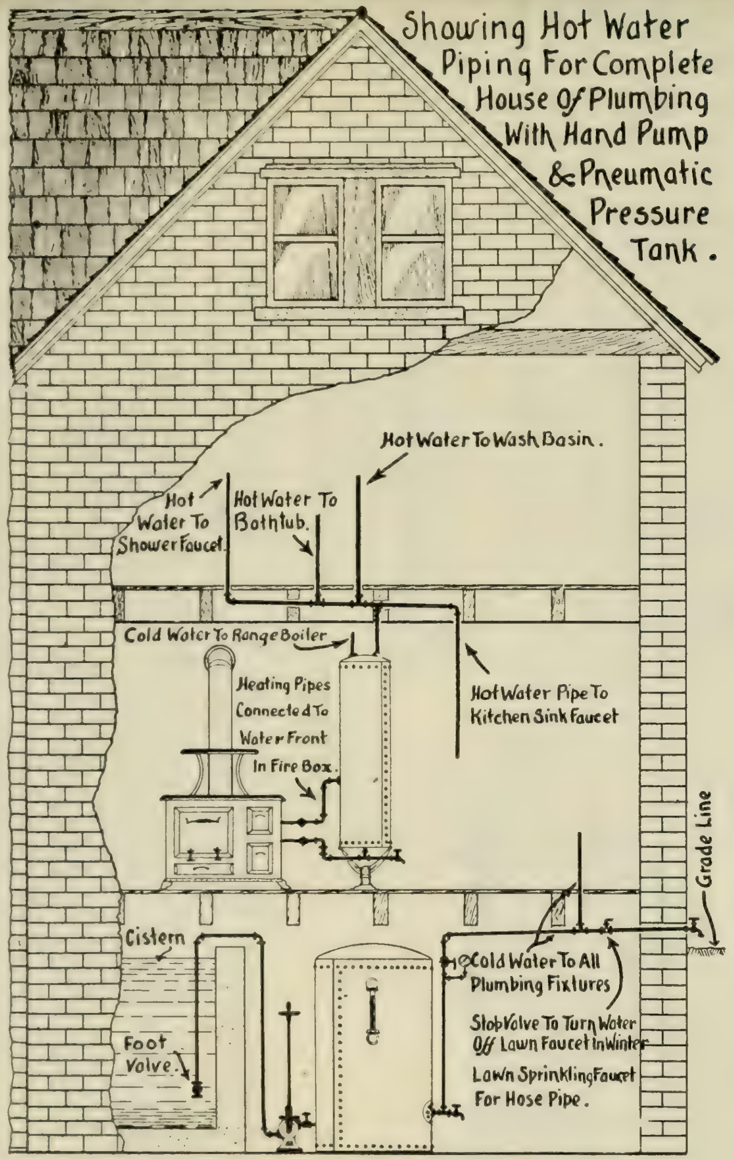

Showing Hot Water Piping For Complete House Of Plumbing With Hand Pump & Pneumatic Pressure Tank.
Hot Water To Wash Basin.
Hot Water To Shower Faucet
Hot Water To Bathtub.
Cold Water To Range Boiler
Heating Pipes Connected To Water Front In Fire Box.
Hot Water Pipe To Kitchen Sink Faucet
Grade Line
Cistern
Cold Water To All Plumbing Fixtures
Stop Valve To Turn Water Off Lawn Faucet In Winter
Lawn Sprinkling Faucet For Hose Pipe.
Foot Valve.

Figure 53

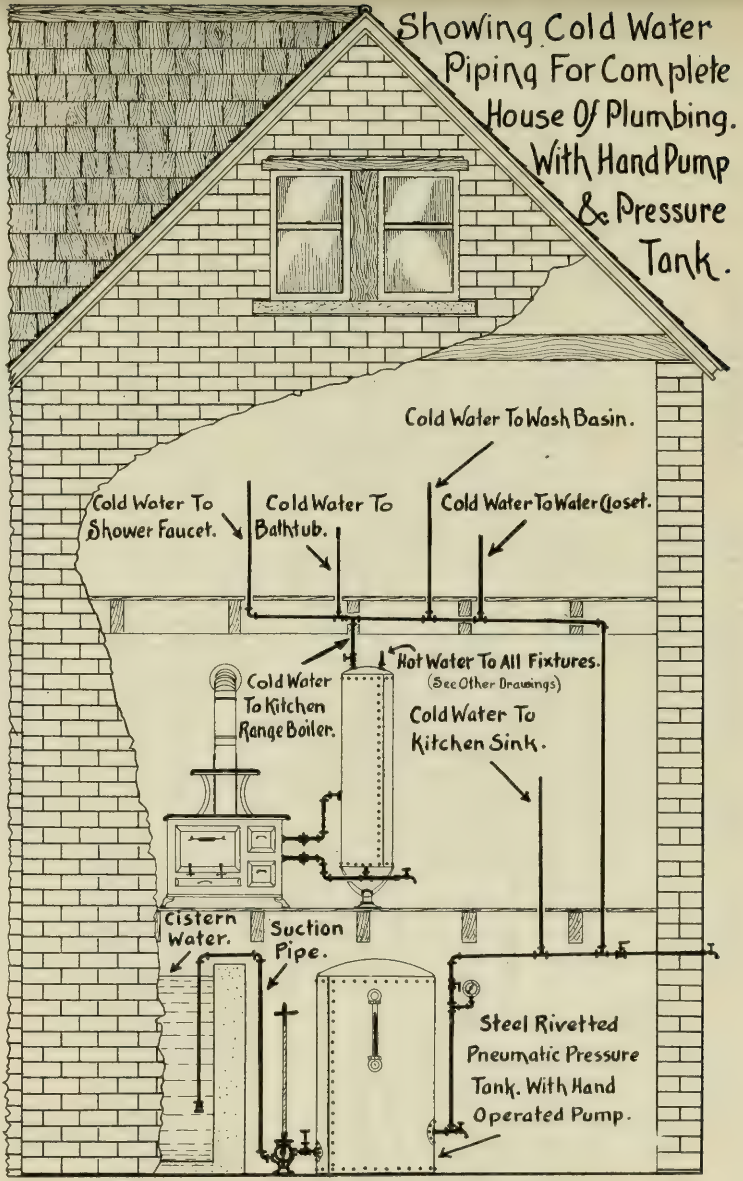

Showing Cold Water Piping For Complete House Of Plumbing. With Hand Pump & Pressure Tank.
Cold Water To Wash Basin.
Cold Water To Shower Faucet.
Cold Water To Bathtub.
Cold Water To Water Closet.
Cold Water To Kitchen Range Boiler.
Hot Water To All Fixtures. (See Other Drawings)
Cold Water To Kitchen Sink.
Cistern Water.
Suction Pipe.
Steel Rivetted Pneumatic Pressure Tank. With Hand Operated Pump.

Fig. 54.

SYSTEMS OF SEWAGE DISPOSAL.

THE CESSPOOL.

Before the advent of the septic tank the cesspool was the only method of sewage disposal for farm homes equipped with plumbing fixtures. In its original and simplest form it was a hole in the ground eight to ten feet deep and four to six feet in diameter, lined up with field stone and safely covered with timbers, plank and earth. Into this pit the sewage was discharged through the inlet pipe and partly decomposed, and in the liquid form slowly seeped away in the surrounding soil. As it was a frequent occurrence for this form of cesspool to overflow, the idea was conceived of improving it by building an enclosed trough around the edge of the pit near the top of the ground and connecting it to rows of field tile, radiating out like the spokes of a wheel, and the liquid was conveyed from the pit to this trough by a three or four-inch pipe between them and turning down a foot or so into the contents of the pit. This is some improvement upon the older form, but not much unless the pit itself is made water-tight to prevent seepage into the soil below.

OBJECTIONS TO THE CESSPOOL.

One serious objection to the cesspool has already been referred to, namely, its overflowing. This condition may be due to a very heavy and poorly drained subsoil, or to too small a pit, or both. The installation of tile already referred to will prevent this trouble for a while, but they soon fill up by the constant dribbling into them of liquid and fine solids. Another bad feature is that wells may be contaminated by the underground seepage from it, and as this seepage may be carried great distances through small channels and the various forms of passages through the soil and rocks below the surface there is ever a lurking danger not only to the water supplies near-by but even to those more remote. If the subsoil be very gravelly and well drained and one could be absolutely certain that there was no chance of the seepage endangering the water supply or reappearing somewhere at the surface as a public nuisance, there could be no serious objection taken to the building of a cesspool, but as the possibilities of trouble with it are so great we cannot recommend it to the general public as a safe and satisfactory method of sewage disposal.

CHEMICAL CLOSETS.

Where there is no running water in the house, and an inside closet is desired, the chemical closet in some form must be used. The two common types are illustrated in Fig. 55 (*a*) and (*b*). Briefly described the chemical closet consists of a receptacle of metal or wood to hold the sewage and a chemical added from time to time to destroy the sewage. The small type shown in Fig. 55 (*b*) is a very simple affair, as may be seen by the figure, and is adaptable for setting up in any convenient place in the home where a vent pipe to the outside can be accommodated. It needs frequent emptying and charging with chemicals, say about once a week, if satisfactory results are to be realized. This kind is quite cheap, about $10 to $15, the price depending upon the size and design.

The design shown in Fig. 55 (*a*) is newer somewhat, more elaborate and costly, but it is very efficient. It is made in a great range of sizes, from that suitable for a private home to large institutions like schools, hospitals, camps, etc. It consists of a metal tank, a nicely designed closet bowl, drop tube and ventilating pipe, and usually an agitator in the tank for mixing up the sewage and chemical. For a house of average size, the tank has a capacity of 125 gallons, and the cost of the complete outfit is in the neighbourhood of $100. This type does not need much attention, the regular thirty-pound charge of chemical being sufficient to sterilize 125 gallons of sewage. Occasionally the sludge has to be removed from the tank.

The Department of Agricultural Engineering will be glad to supply further information regarding chemical closets, particularly in respect to different makes, names of firms selling them, etc.

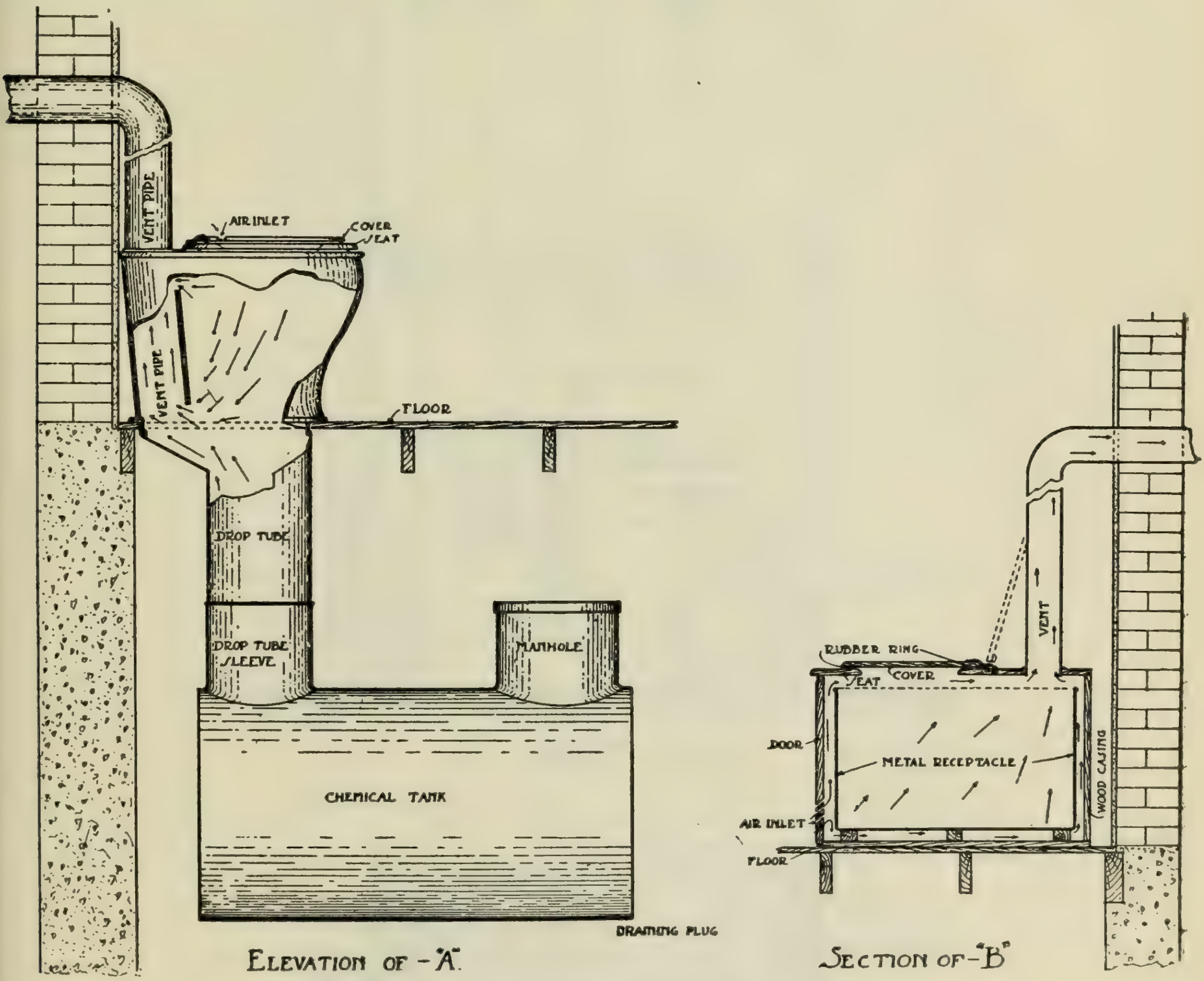
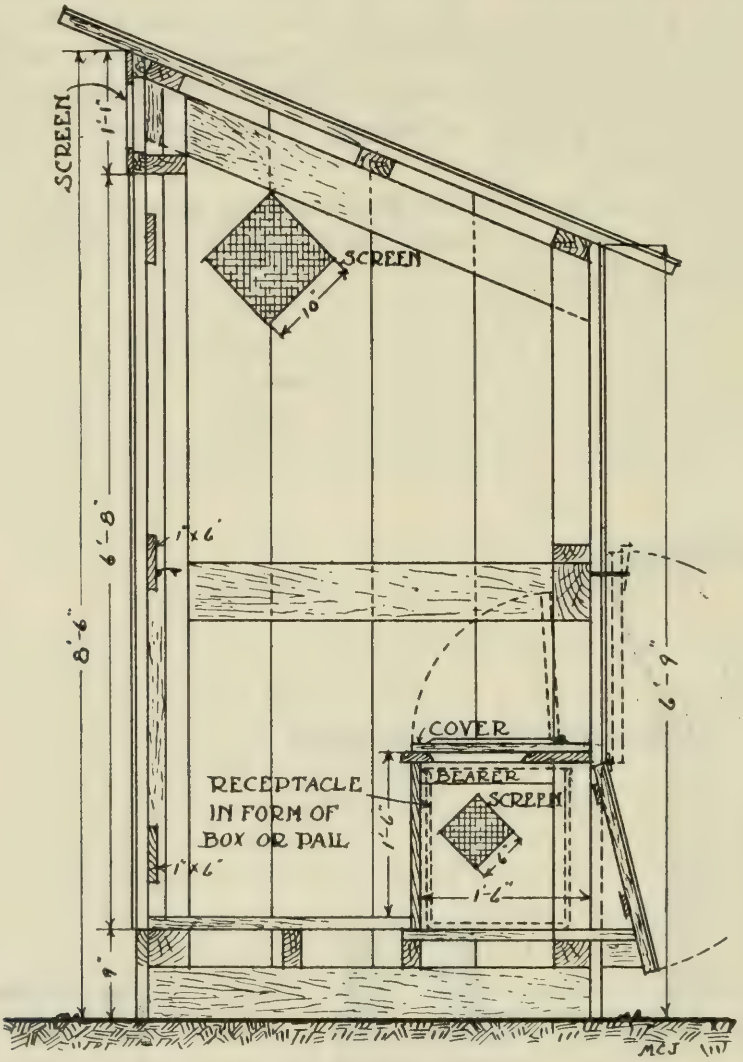


Fig. 55.—Two types of chemical closets.

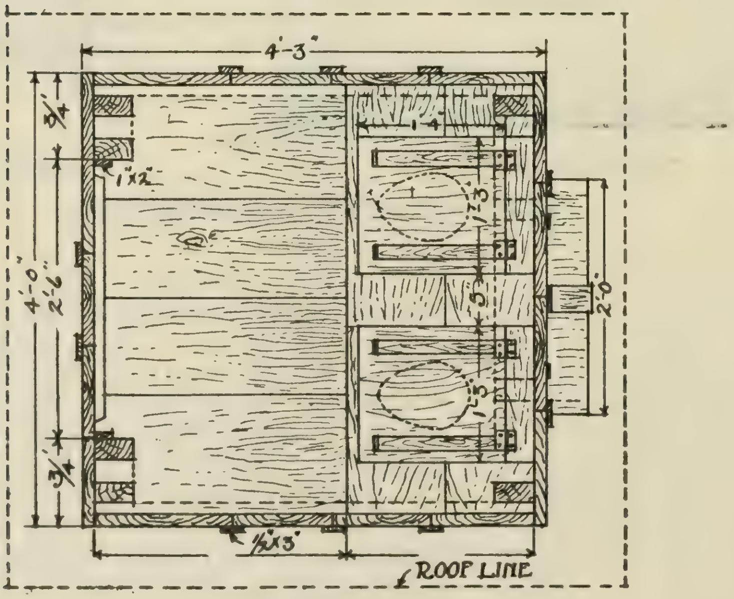
TYPES OF OUTSIDE PRIVIES.

The two most satisfactory types of outside privies are illustrated in Figs. 56 and 57. The chief difference between them is in the kind of receptacle used; in the former it is a pail or box, while in the latter an underground water-tight vault. These designs are recommended by the Provincial Board of Health, Parliament Buildings, Toronto, and a full treatment of the subject is given in their circular No. 9, entitled "Rural and Semi-Urban Sanitation," which may be had on application to them. As the accompanying figures give all the details and measurements no further description is necessary.

In order to make these privies as sanitary as possible they should be built fly-proof and screens put in the door and on opposite sides, as shown in the drawings, for purpose of ventilation. The receptacles should be cleaned out often and they should be disinfected each time with chloride of lime, and dry ashes may be used regularly on the contents of the receptacle or vault with good results.



SECTION



PLAN

Fig. 56.—Section and plan of outside privy.

If the privy is built and attended to as herein specified it may be located quite close to the house, preferably inside or attached to the woodshed to avoid undue weather exposure to those using it. The purposes of the waterproof underground vault are threefold: to prevent the seepage of contamination underground to the well, to increase the storage capacity for sewage and make less frequent cleaning possible, and, lastly, to keep out flies.

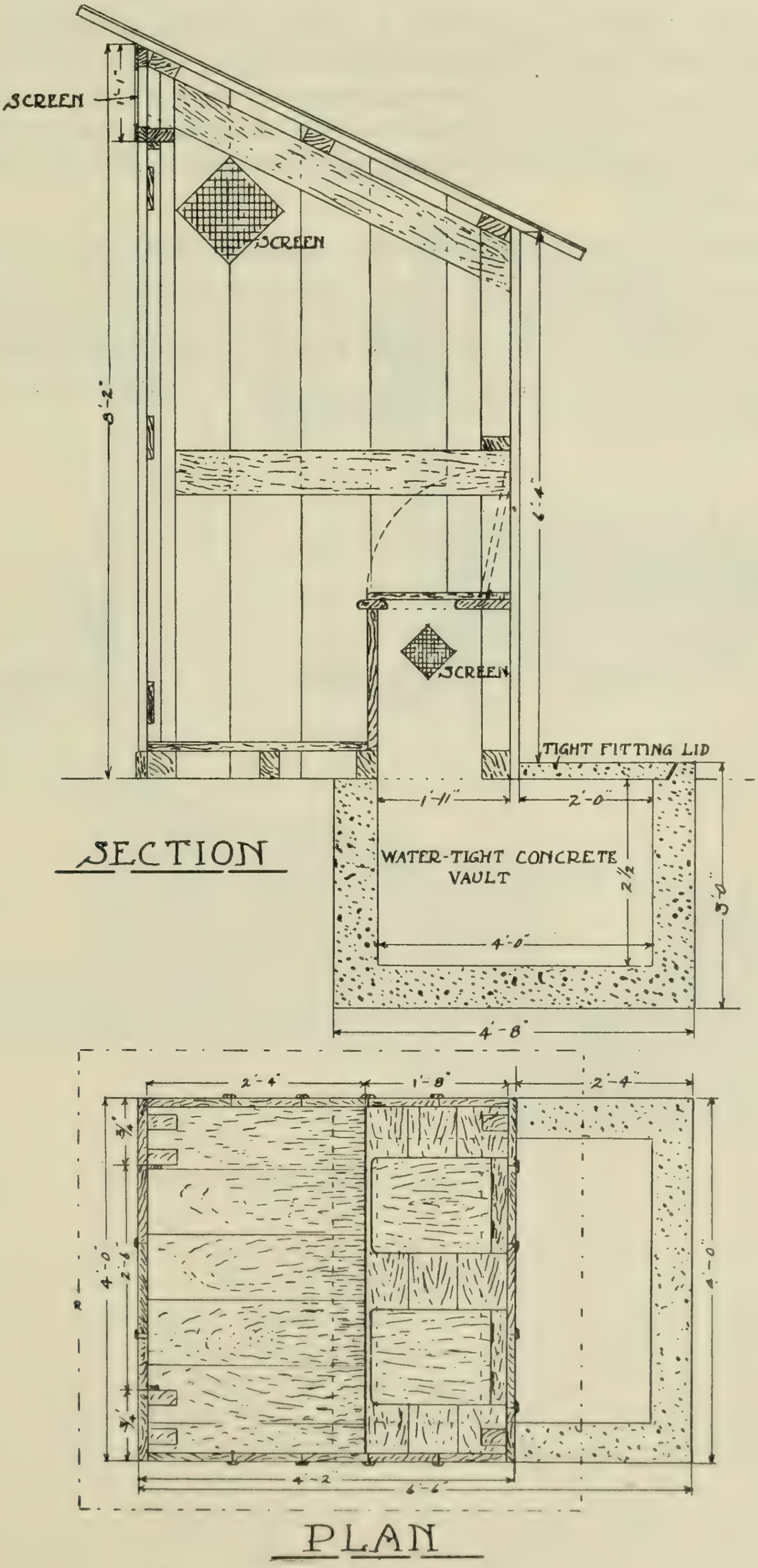


Fig. 57.—Section and plan of outside privy.

SEWAGE DISPOSAL IN RELATION TO PUBLIC WATER SUPPLY.

Those who intend to install sewage systems should bear in mind carefully the fact that our water supplies are protected by law against sewage contamination. The articles in The Public Health Act that pertain to this case are given herewith as follows:

"*Article 90.*—The Provincial Board shall have the general supervision of all springs, wells, ponds, lakes, streams or rivers used as a source for a public water supply with reference to their purity together with the waters feeding the same, and shall examine the same from time to time when the necessity for such examination arises, and inquire what, if any, pollution exists and the causes thereof. 2 Geo. V, c. 58, s. 90.

"*Article 91.*—(1) No garbage, excreta, manure, vegetable or animal matter or filth shall be discharged into or be deposited in any of the lakes, rivers, streams or other waters in Ontario or on the shores or banks thereof."

Therefore it is the duty of all parties putting in any form of sewage disposal systems to strictly guard against any possibility of them directly or indirectly contaminating the sources of public water supply.

GREASE TRAPS FOR KITCHEN AND LAUNDRY WASTE WATER.

In farm kitchens there are large quantities of waste water to be disposed of daily in some way or another. In homes equipped with septic tank or cesspool these wastes may be discharged into them, although there is some objection to this practice, in the case of the wash water for the reason that it contains much strong alkali material which is injurious to the sewage bacteria both in the tanks and in the soil. For homes without septic tanks these forms of waste may be disposed of in a convenient and sanitary manner in a grease trap or miniature cesspool, two types of which are illustrated in Fig. 58. The upper type is best adapted to heavy soils, and it will be necessary in this case to install a small bsorption bed of thirty or forty three-inch or four-inch drain tile on the same rinciple as for a septic tank. The trap may be located close to the cellar wall and he tile ten or more feet away. The lower type is adapted to light, gravelly soil r any soil with a very porous subsoil well drained. It should be built fifteen or wenty feet away from the house. The top of the trap in either case should be trong, tight fitting and removable in order that the trap may be readily accessible t any time for cleaning out the accumulation of grease and sediment whenever ecessary. Neither one of these types is difficult or expensive to construct and ieir installation at any farm home not having sewage disposal systems would id materially in making conditions tidy and sanitary about the back door.

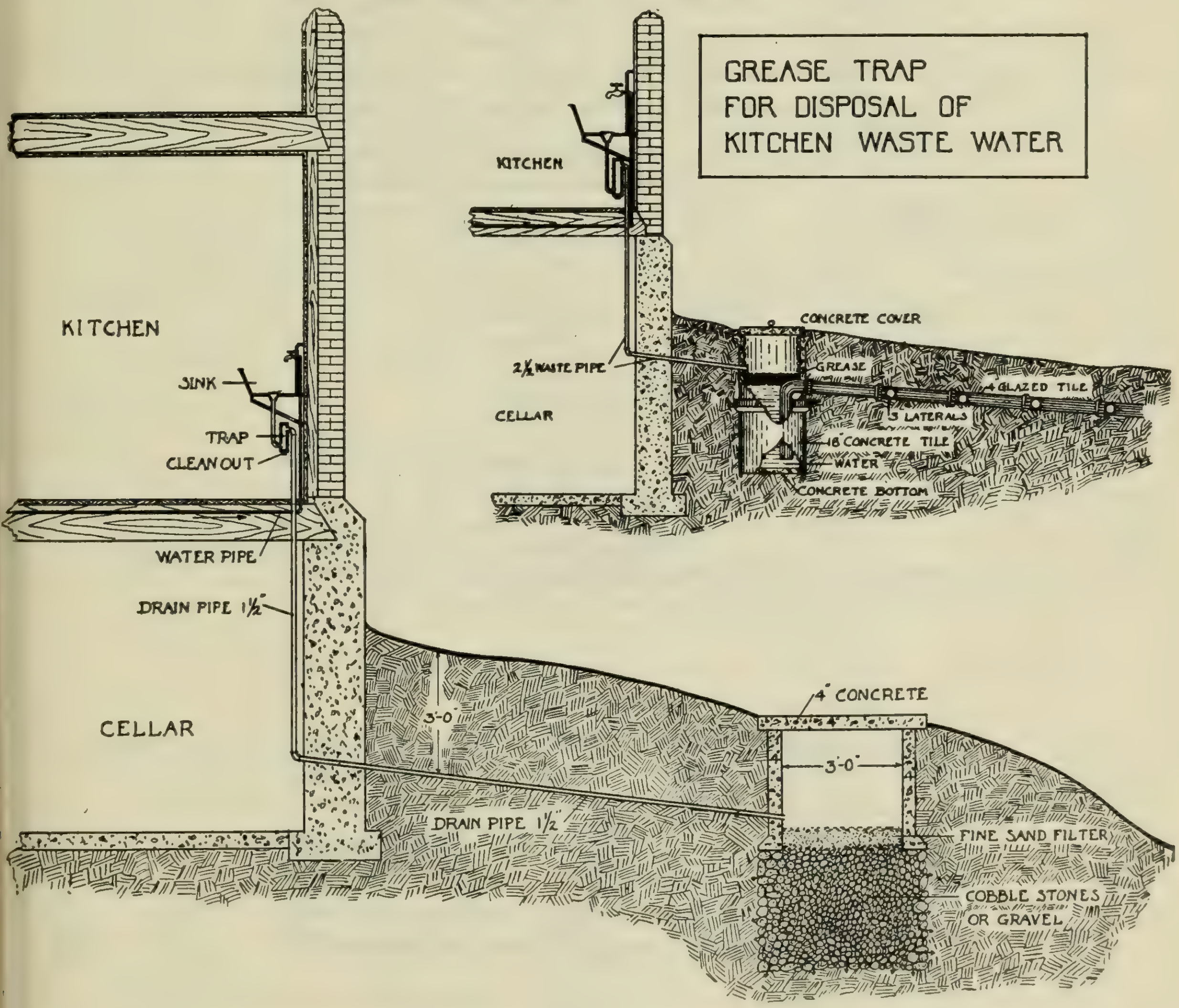
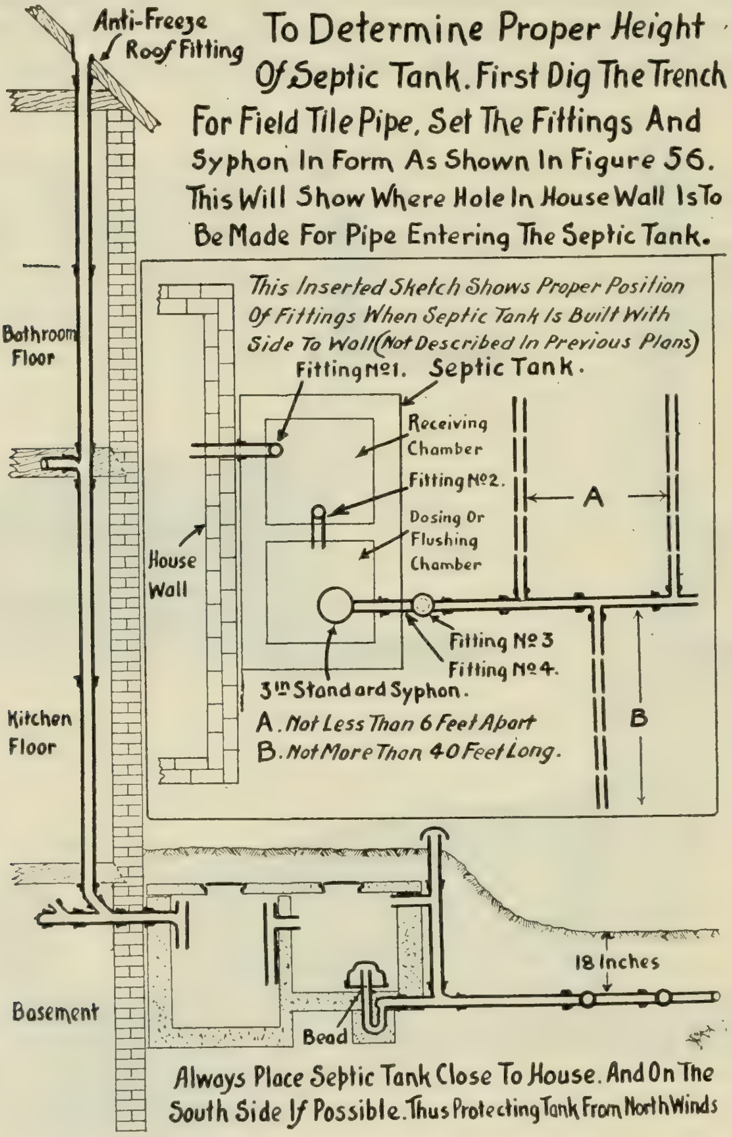


Fig. 58.—Two types of grease trap for disposal of kitchen waste water.

THE SEPTIC TANK SYSTEM OF SEWAGE DISPOSAL

This system is recognized by all provincial boards of health and sanitary engineers as the best for disposing of sewage from rural, village, and suburban homes, or any home, school, or institution not served by a municipal sewerage system. It, however, cannot be used except where there is a water supply and modern conveniences in the home or other place of human habitation.


To Determine Proper Height Of Septic Tank. First Dig The Trench For Field Tile Pipe, Set The Fittings And Syphon In Form As Shown In Figure 56. This Will Show Where Hole In House Wall Is To Be Made For Pipe Entering The Septic Tank.

This Inserted Sketch Shows Proper Position Of Fittings When Septic Tank Is Built With Side To Wall (Not Described In Previous Plans)

A. *Not Less Than 6 Feet Apart*
B. *Not More Than 40 Feet Long.*

Always Place Septic Tank Close To House. And On The South Side If Possible. Thus Protecting Tank From North Winds

Fig. 59.

General Description

Briefly stated, the septic tank is a two-chamber tank or receptacle for receiving the sewage and holding it until digested by sewage bacteria, and a system of field tile connected thereto, and laid under the ground for disposing of the liquid effluent discharged from the tank from time to time. For the most part the sewage is destroyed in the receiving chamber; however, there is some bacterial action in the other chamber, and in the soil as well. The chief products of the bacterial action in the tanks are gases and water. Disease germs may survive the action in the tank, but ultimately they succumb in the soil.

CONSTRUCTION OF THE TANK

As a rule it is of concrete construction, a 1 to 6 mixture being used. The plans (Fig. 60) and the subjoined table supply the necessary information as to dimensions, thickness of walls, amounts of gravel and cement, etc. The forms are simple and easy to build, and outer ones are not necessary except above the surface. The forms should be made true, and be well braced. The fittings should be placed in the forms at positions indicated in Fig. 61, and before the concrete

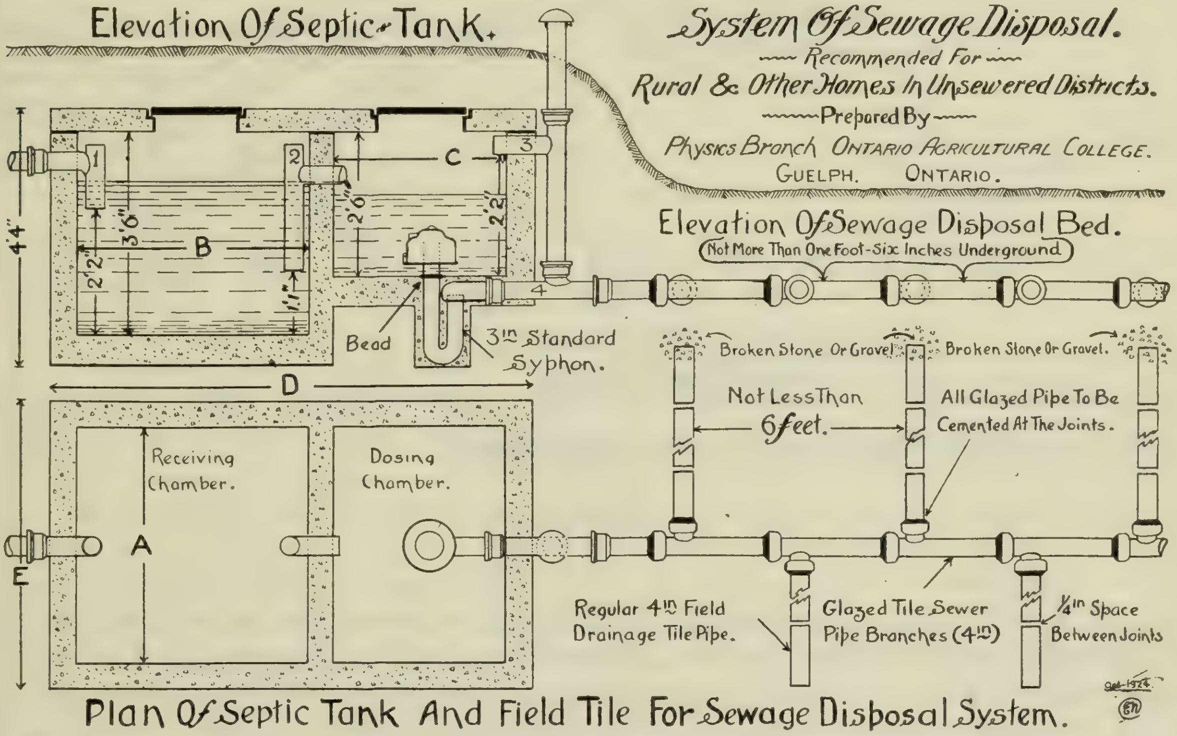

Elevation Of Septic Tank.
System Of Sewage Disposal.
Recommended For
Rural & Other Homes In Unsewered Districts.
Prepared By
Physics Branch Ontario Agricultural College.
Guelph. Ontario.
1
2
3
4
C
B
A
D
E
4'4"
3'6"
2'2"
2'6"
2'2"
1'1"
Bead
3in Standard Syphon.
Elevation Of Sewage Disposal Bed.
(Not More Than One Foot-Six Inches Underground)
Broken Stone Or Gravel
Broken Stone Or Gravel.
Not Less Than 6 feet.
All Glazed Pipe To Be Cemented At The Joints.
Receiving Chamber.
Dosing Chamber.
Regular 4in Field Drainage Tile Pipe.
Glazed Tile Sewer Pipe Branches (4in)
¼in Space Between Joints
Plan Of Septic Tank And Field Tile For Sewage Disposal System.
Oct 1924

Fig. 60.

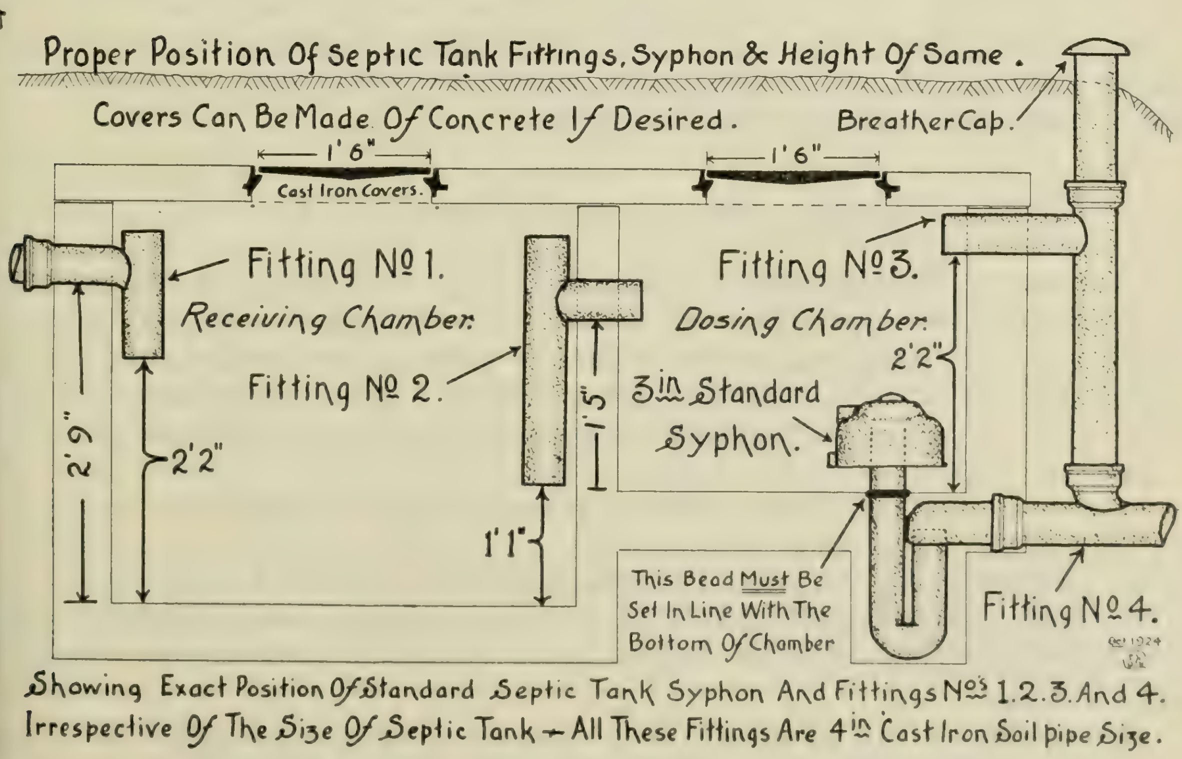

Proper Position Of Septic Tank Fittings, Syphon & Height Of Same.
Covers Can Be Made Of Concrete If Desired.
Breather Cap.
1'6"
1'6"
Cast Iron Covers.
Fitting No 1.
Receiving Chamber.
Fitting No 2.
Fitting No 3.
Dosing Chamber.
2'2"
3in Standard Syphon.
1'5
2'9"
2'2"
1'1"
This Bead Must Be Set In Line With The Bottom Of Chamber
Fitting No 4.
Oct 1924
Showing Exact Position Of Standard Septic Tank Syphon And Fittings Nos 1.2.3. And 4.
Irrespective Of The Size Of Septic Tank — All These Fittings Are 4in Cast Iron Soil pipe Size.

Fig. 61.

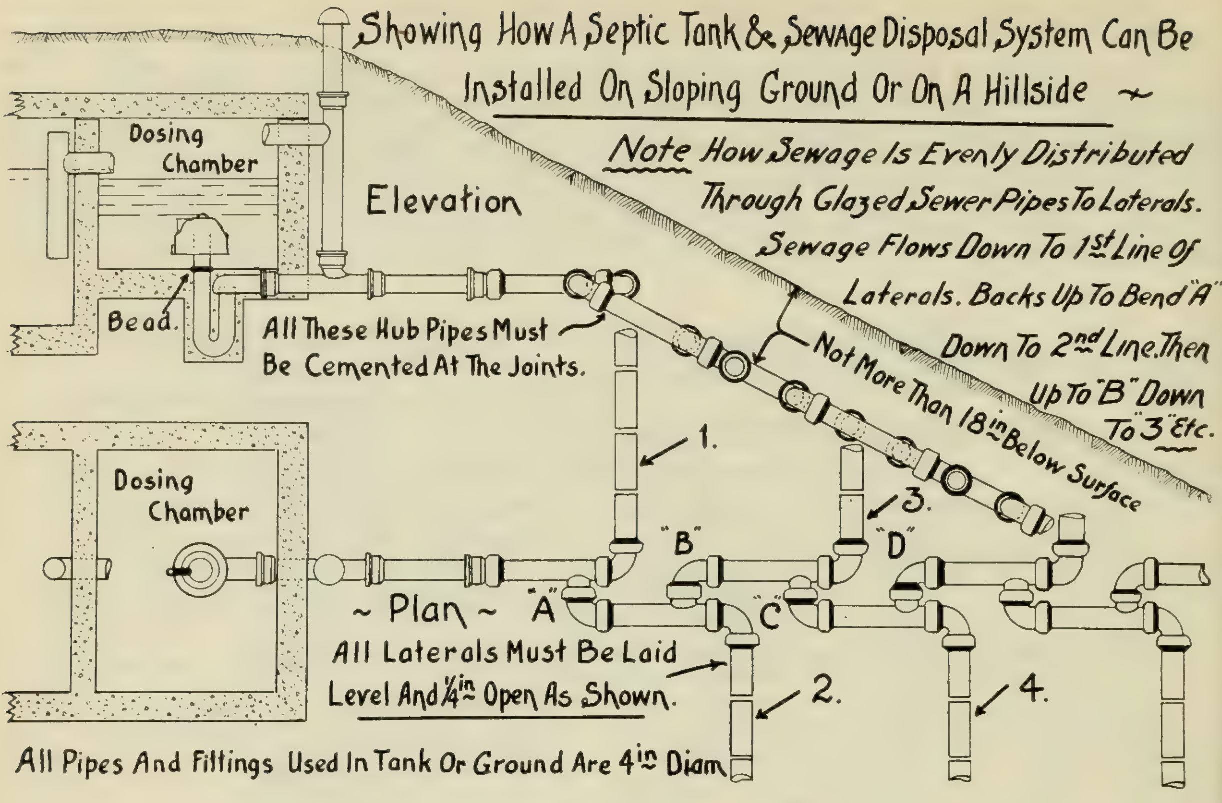

Showing How A Septic Tank & Sewage Disposal System Can Be Installed On Sloping Ground Or On A Hillside
Note How Sewage Is Evenly Distributed Through Glazed Sewer Pipes To Laterals. Sewage Flows Down To 1st Line Of Laterals. Backs Up To Bend "A" Down To 2nd Line. Then Up To "B" Down To 3 Etc.
Dosing Chamber
Elevation
Bead.
All These Hub Pipes Must Be Cemented At The Joints.
Not More Than 18in Below Surface
1.
"B"
3.
"D"
Dosing Chamber
~ Plan ~
"A"
"C"
All Laterals Must Be Laid Level And 1/4in Open As Shown.
2.
4.
All Pipes And Fittings Used In Tank Or Ground Are 4in Diam.

Fig. 62.

is run into the forms. The U-part of the siphon should be placed vertical and near the outer end of the chamber, and with the bead on a level with the finished surface of the floor. The entrance to the vertical tube of the siphon should be plugged to keep objects from falling into it during the construction of the system. After the forms have been removed, the interior surfaces should be plastered with rich cement mixture (one to one) to make tank water-tight. After this the top or cover is constructed with accommodation for two manholes. In the top of the partition wall there should be two or three openings to permit of air passing from one chamber to the other unless standard fittings as shown in Fig. 61 are used, when openings may be omitted.

Construction of the Absorption Bed

An area of ground about 25 feet by 50 feet is required for the bed or system of tile for the average-sized home. If the soil be very heavy or apt to become water-logged it should be tile-drained first by putting two parallel rows of three or four-inch tile at a depth of two and a half feet and joining them to a good outlet. The main line of tile of the absorption bed may run through the centre of the area or along one side. The branches should be four or six feet apart and not more than forty feet long, and the joints left about one-quarter inch open. The whole system should be practically level and not deeper than eighteen inches. The joints in the main should be cemented. Vitrified sewer pipe is used for the main and four-inch field drainage tile for the branches. In heavy soil it will help to put a few inches of cinders, gravel or broken stone around the tile to assist drainage.

The system of tile may be laid in terraced or sloping ground if necessary, but it is not a common occurrence. One system is shown in Fig. 62.

DETAILED CHART FOR SEPTIC TANK

Number of Persons to Occupy House	Reference Letters A		B		C		D		E		Lineal feet of Field Tile	Materials required using 1-2.4 Mixture	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	4 in.	Sacks of Cement	Loads of Gravel
Four	3	6	4	0	3	0	8	4	4	6	150	16	3
Six	4	0	5	0	5	0	11	2	5	0	285	22	5
Eight	4	0	6	0	6	6	13	10	5	0	375	26	6
Ten	5	6	5	6	6	0	13	4	7	0	470	35	8
Twelve	6	6	6	6	6	6	14	10	8	0	605	58	12

NOTE.—Six-inch walls for the first three tanks and 8-inch walls for the last two.

TANK FITTINGS

These parts comprise the siphon, the inlet, the overflow in the partition wall, and the ventilation pipe, all clearly shown in Fig. 61. The siphon is commonly known as the Miller design, and may be purchased from plumbers or hardware men. The other fittings may be assembled on the spot from pieces of four-inch cast-iron pipes, or they may be purchased as standard tank fittings similar to those shown in Fig. 61. The complete set, including the siphon, costs about $35 on the market. It is very essential to have all fittings correctly installed, and for this reason Fig. 61 is shown with all details and measurements emphasized.

The siphon empties the second chamber automatically when liquid gets about sixteen inches deep. It helps in keeping the tile system flushed out and ventilated and thereby making conditions in the soil more favourable for bacterial action. The U-part of the siphon should be filled with water, or primed, before the bell is set on.

LOCATION

The tank should be placed near the house, and preferably on the south or warm side. If convenient, it may be placed tight to the foundation wall, either endwise or sidewise, as shown in illustration. If the system be properly installed there should be no odour from the tank. The tank should be easily accessible for the purpose of opening up or cleaning out when necessary. The top should be kept covered with about six inches of soil or turf.

The absorption bed may be laid under the flower or vegetable garden, the lawn or any convenient place near by. It should be kept away as far as possible from the water supply and roots of bushes and trees. It may be placed close to the tank or farther away, depending on conditions.

WHERE TO BEGIN IN LAYING OUT THE SYSTEM

The purpose of Fig. 59 is to show the connection of the system to the soil pipe in the house, on the one hand, and the lay of the land about the house, on the other. According to it, the depth of the trenches for the tile should be determined first of all; then the bottom of the excavation of the siphon chamber should be fixed a few inches higher; then if the fittings are placed at their proper positions, as shown in Fig. 61, the point where the soil pipe passes through the foundation wall is automatically determined. If the land is quite level, the tank when finished will project some above the ground level; if so, it will be necessary to bank it up and cover.

COST

The cost will be determined by the size of the system and the amount of material and labour that has to be purchased on the market. If a farmer had his own gravel and field tile and did all the work himself, the cash outlay for a suitable size should not exceed $50. A contract price including everything would be about double this amount.

SOME EXPERIENCES REVIEWED

It pays well to make a first-class job of installing the system, as it will last much longer and give much better service.

In the colder sections, and particularly in those places where there is not much snow, it is advisable to cover the tank and the absorption bed during the winter with a few inches of strawy horse manure or straw. A porous covering should also be used about the top of the vent pipe, but it must not be closed tight.

It is better to err on the side of building the tank oversize than too small, as the family may be larger some day, and our experience is that septic-tank troubles are often traceable to overloading by being too small.

Too much soapy water and greasy material from laundry waste are injurious to the bacteria in the tank, and, if possible, these should be discharged into a separate cesspit. Strong disinfectants are likewise harmful and, therefore, they should be used sparingly and flushed out with much water.

Heavy and poorly drained soils are not suitable for septic tank systems. In many cases they can be made all right by underdrainage and the use of porous material like gravel, cinders, etc., used around the tile.

Lawns and vegetable and flower gardens are benefited by having the absorption bed below as it serves as sub-irrigation and supplies some soil fertility.

The digestion chamber of the tank should not be disturbed except to remove occasionally the accumulation of sludge from the bottom of the tank.

The siphon should be inspected once or twice a year to make sure that it is working satisfactorily, but unless the tank becomes overloaded or choked for some reason, the siphon can be depended upon to carry on successfully.

There are good reasons why you should *not* empty effluent of septic tanks into a near-by stream, open ditch or highway tile drain in lieu of the absorption bed. The latter system is the safest in all instances.

BACTERIAL ACTION IN THE SEPTIC TANK SYSTEM OF SEWAGE DISPOSAL.

D. H. JONES, PROFESSOR OF BACTERIOLOGY.

The private house septic tank system of sewage disposal may be considered to consist of four sections. First, there is the collecting system composed of the toilet basin, bath and wash basins (laundry water should not be allowed in); second, the first compartment of the septic tank, known as the settling chamber; third, the second compartment of the septic tank, known as the discharge chamber, and fourth, the sub-irrigation tile system into which the sewage from the tank is discharged. Bacterial action in these various sections differs to some extent and is very marked in all but the first. To gain an idea of what bacteria are, their nature, size, etc., the reader is referred to Fig. 63, Nos. 1, 2, 3 and 4.

Crude sewage consists of water, plus organic and mineral solids, both in suspension and solution. Purification of the sewage implies the removal or destruction of these organic and mineral substances, leaving an effluent of pure water. In the septic tank system this purification is induced by the bacteria present.

Sewage has a very rich and complex bacterial flora. It contains millions of bacteria in every cubic centimeter, and many species are represented in this number. When the action of these bacteria is properly controlled, it results in the complete purification of the sewage. The septic tank system has been devised for the purpose of adequately controlling the action of the sewage bacteria to the end, first,that the sewage may be purified, and,second,that as much manurial value as is possible under the circumstances may be obtained from the sewage.

The bacteria responsible for this purification process may be divided into three main groups, according to their oxygen requirements: First, the anaerobic bacteria; second, the aerobic; and, third, the facultative bacteria. The anaerobic bacteria are those species which are active only in the absence of oxygen; the aerobic bacteria are those which are active only when oxygen is present, and the facultative bacteria are those species which are active either in the presence or absence of oxygen.

The settling chamber of the septic tank remains always full. As the sewage enters this chamber at one end the heavier solids settle to the bottom and the excess liquid from the tank passes over into the discharge chamber at the other end. The bacterial action which takes place in the settling chamber is mostly due to the action of the anaerobic species of bacteria which find favourable conditions for their work in the lower depths of the sewage, where free oxygen is not present. Here they accumulate in large numbers and their work consists mostly in reducing or partially breaking down or digesting, by extraction of oxygen, the complex organic matter present in the solids, changing it to simpler and soluble substances which are then ready to pass over in liquid form into the discharge chamber. In this action, gases such as carbon dioxide and hydrogen sulphide are produced, which bubble up through the liquid. In the surface layers of this chamber the aerobic and facultative species of bacteria are also active, to some extent, as oxygen is there available. Their action results in a digestive process, mostly by oxidation of the organic materials present. As a result of their activities in the surface layers using up the oxygen that is present, they ensure strict absence of air in the lower depths, thus making ideal conditions for the anaerobic bacteria.

In the discharge chamber the bacterial action is not so decided as in the settling chamber, for the simple reason that the oxygen requirements are not at the maximum and the contents of this chamber are discharged once or twice daily. Nevertheless, bacterial action is progressing constantly in the sewage of this tank as it slowly increases in volume to the time when it is discharged. The classes most prominent in this chamber are the aerobic and facultative bacteria. Their action is a further breaking down or digesting by oxidation of the organic material still present in the sewage, both in soluble condition and also solids in suspension.

As soon as the contents of the tank are discharged into the sub-irrigation tile system, the liquid is slowly absorbed by the soil around the tiles and by capillary action a film of the liquid covers the individual soil particles, and through this thin film the oxygen of the soil air is readily available to the bacteria in the film, enabling them to complete their action in breading kown the complex organic substances still remaining. Then, the nitrifying bacteria and others, some of which are in the sewage, but more of which are in the soil, recombine the elements and simple compounds thus formed into fresh compounds, as nitrates, which may then be utilized by growing plants. In this way much of the manurial value of the sewage is reclaimed in the soil and the drainage water from such soil, if there is any, should be relatively, if not absolutely, pure, providing the system is working properly. Needless to say the tile system should not be allowed to clog up and the soil surrounding it should be more or less porous and not heavy clay.

Bacterial Action in the Dry Closet.

The satisfactory disposal of human excreta is frequently a troublesome problem both in individual houses in the country and in dense town or city communities. The excreta contains considerable manurial value, as it is composed almost entirely of organic material in process of decay. It contains millions of bacteria to the ounce and it is the activities of these bacteria that are responsible for its putrefaction and decay. If allowed to accumulate as in dry closets or outhouses, it becomes a decided nuisance with objectionable odors and serves as a breeding place for flies and other insects. If these closets were kept clean, the contents being removed weekly and buried six inches to a foot beneath the surface of the soil in field or garden, the nuisance would not occur. When the excrement is allowed to accumulate, the action of the various anaerobic species of bacteria within the mass results in the production of the strong smelling gasses, whereas if it is not allowed to accumulate but is buried in small quantities just beneath the surface of the soil, the aerobic species of bacteria bring about its decay without the production of the strong odours and its full manurial value is recovered in the soil.

Bacterial Action in Cesspools.

In the cesspool, sewage is not thoroughly purified, as the bacterial action is incomplete, being mostly anaerobic and very similar to that in the settling chamber of the septic tank. As the walls of the cesspool are permeable to water, the sewage soaks away directly into the surrounding subsoil. When this becomes water-logged the sewage rises more or less to the surface, thus becoming a nuisance, giving foul odours and bogginess. As the bacterial action in the cesspool is mostly, if not altogether anaerobic, the decomposition of the sewage is only partial. If the surrounding soil is fairly porous and does not become water-logged, there will be some aerobic bacterial action in the upper layers of the soil which will tend to purify the sewage should it reach those upper layers. But this action cannot be regulated or depended on and the drainage water from such soil is liable to be heavily contaminated with undesirable sewage bacteria with sewage only partially purified. Hence wells should never be located near a cesspool.

Description of Fig. 63.

1. *Bacillus fluorescens*, fairly common in well water.
2. *Bacillus subtilis* (hay bacillus), common on hay and in the soil; occasionally found in well water.
3. *Bacillus coli*, common in sewage and in polluted water; the danger signal in water examination.
4. *Bacillus typhosus*—showing flagelia. Cause of typhoid fever.
5. Flask of culture media, test-tube culturs, inoculating needles, petri dish cultures, high power microscope. (Edwards.)

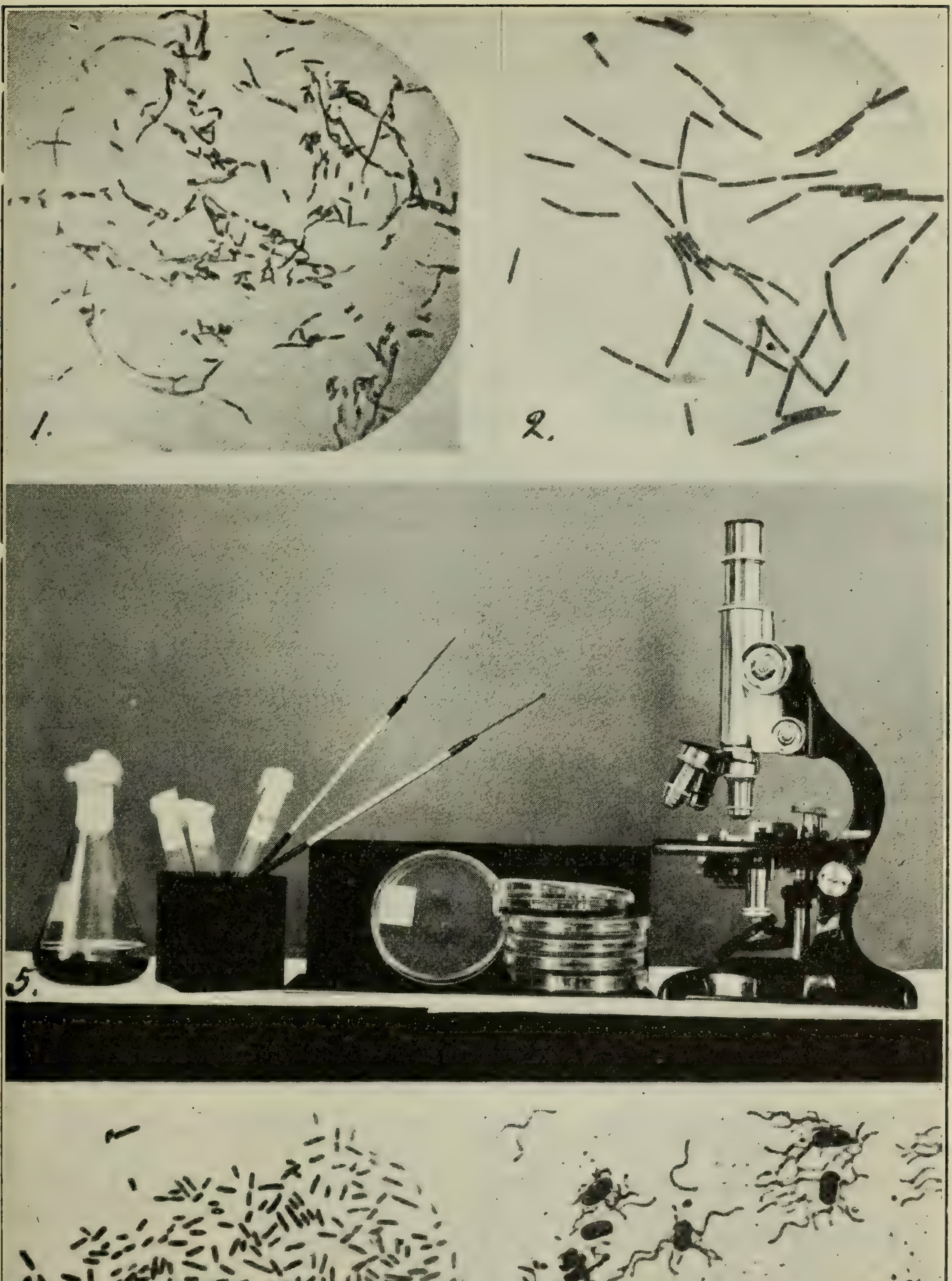


Fig. 63.

BACTERIA AND THE WATER SUPPLY.

D. H. Jones.

Bacteria are microscopical plants. They are the smallest living things known. They average about 1/5000 of an inch in length and 1/15,000 of an inch in breadth. They are invisible except when viewed through a high power microscope, hence the term microscopical. They are very simple in structure, being unicellular. In shape some are spherical, some are straight rods, and some are spiral. See Fig. 63, Nos. 1, 2, 3 and 4. Under favourable conditions for growth they multiply very rapidly. One bacterium may have a progeny of from ten millions to fifteen millions in twenty-four hours. They occur in large numbers wherever man, animal or plant life exists. There are many species of them, the majority of which are beneficial, but some species, however, are injurious. Amongst the latter are those which cause most of the infectious diseases of man and animals. Sometimes these injurious species get into the water supply and as a result an epidemic of infectious disease, as typhoid fever, is liable to occur.

All natural drinking waters, such as rivers, ponds, lakes, wells, etc., usually contain many species of bacteria. Other micro-organisms, such as algæ, diatoms and crustacea are also likely to be present. Some of the bacteria may be harmful to health, being liable to cause disease, but many of them are not. It is the presence of these dangerous species in the water supply that has to be guarded against.

The species of bacteria found in drinking waters are divided into three more or less distinct groups, as follows:

Group I. Natural Water Bacteria.

This group includes a number of species of bacteria which are not harmful to health. They are liable to develop and multiply in water in which there is a minimum of organic matter, but as they cannot cause disease their presence is not sufficient to condemn the water for drinking purposes.

Group II. Soil Bacteria Found in Water.

In the soil there are many different species of bacteria. See Fig. 63, Nos. 1 and 2. One ounce of soil will contain millions of them. These find their way into rivers, lakes, wells, etc., during rains, particularly at flood time, being washed from the soil both in the surface and drainage waters. These bacteria do not live and multiply in the water to any great extent unless there is a considerable amount of organic matter present in it. They do not produce disease hence their presence alone in water is not sufficient to condemn it for drinking purposes, though if they are present in any quantity they indicate either that there is considerable organic matter present, or that there is danger of the water being polluted from soil surface washings, which may have been contaminated with disease-producing bacteria coming from infected persons. Neither of these conditions is desirable.

Group III. Intestinal Bacteria Found in Water.

In the intestines of man and animals there are certain species of bacteria particularly *Bacillus coli*, normally present in very large numbers. See Fig. 63 No. 3. These are passed out by the million in the bowel discharges, so that when the water supply becomes contaminated with sewage from cesspools, drains, or seepage, there will be many contaminating bacteria present in the water. These bacteria do not multiply to any great extent in natural waters as the food and temperature conditions of the water are not usually suitable for their multiplication.

Thus, when *Bacillus coli* or any other species of intestinal bacteria is found in water it is an indication that the water has been recently polluted and may be dangerous. *Bacillus coli* itself is not, except under certain conditions, a disease-producing bacillus, but wherever it is found in water there is danger of *Bacillus typhosus* (Fig. 63, No. 4), which causes typhoid fever, being present. Many outbreaks of typhoid fever are due to the water supply being polluted with the discharges from either a typhoid patient or typhoid "carrier." A typhoid carrier is one who has had typhoid fever and has got better, but has not got rid of the typhoid bacteria from his system. Within his system the bacteria are constantly developing and being discharged in the urine and fæces. Water, milk, or any kind of food that becomes contaminated from such discharges is liable to establish typhoid fever in those consuming the food. Hence, great care is necessary to prevent water and foods from being so contaminated.

Shallow or dug wells are very liable to such contamination unless they are properly located and constructed. They should be so located that surface drainage cannot find entrance and the upper ten or twelve feet of the wall should be impervious to water, thereby forcing all water that enters the well to filter through soil to a depth of at least ten or twelve feet, a process which aids in purifying it.

When wells have become polluted from unsanitary seepage or drainage the cause should be found and removed and preventive measures taken so that the trouble should not recur.

The water so polluted should be sterilized, that is, should have all the bacteria killed before being used for drinking purposes. Sterilization may be accomplished either by boiling the water or by the addition of a suitable disinfectant. The disinfectant most suitable for this purpose is a hypochlorite solution. This hypochlorite solution may be prepared and applied as follows:

Stock Hypochlorite for Water Purification.

1. Mix ½ pound of chloride of lime (33 per cent. available chlorine) with 1 pint of water.
2. Then add sufficient water to make 1 gallon.
3. Dissolve 13 oz. of sal soda crystals in 2 quarts of lukewarm water.
4. Add sufficient water to make 1 gallon.
5. Mix these two solutions in a barrel or crock and allow the milky solution to settle over night.
6. Pour off the clear liquid from the white sediment into a jug and fill into bottles, well stoppered, and keep cool in a dark place. This "stock hypochlorite" will contain approximately the equivalent of three per cent. of chloride of lime or one per cent. of available chlorine.

Application. Mix one ounce of this stock solution to five gallons of water that is to be used for drinking purposes. After mixing, allow to stand for half an hour before use.

The solution may be added in small quantities to water after it has been drawn from the well or the quantity of water may be estimated and the necessary amount of solution poured direct into the well and stirred in.

FREE BACTERIOLOGICAL TESTS MADE.

Farm well waters suspected of being polluted will be tested upon application to the Bacteriological Laboratory, Ontario Agricultural College.

TAKING A SAMPLE OF WELL WATER FOR BACTERIAL ANALYSIS.

In procuring samples of water for bacterial analysis great care must be taken that they be not contaminated by bacteria from the hand, clothing, etc. To this end full directions for sampling are given in Appendix 3, and they should be followed in every detail. Also full information about the well should accompany the sample. Forms as outlined in Appendix 5 will be supplied on application to the Department of Agricultural Engineering, O.A.C., Guelph.

CHEMISTRY OF THE FARM WATER SUPPLY.

H. L. FULMER.

Water, as we see amd use it every day of our lives, is a very simple looking substance, and most people through daily association with it undoubtedly come to look upon it, or consider it to be, as simple and as harmless as it appears.

In reality, however, water that we find in our wells, springs, streams, rivers, lakes and oceans is a rather complex liquid, being often composed of many things mixed together. Some of the things present frequently are of a nature, or have in possession some property which they impart to the water as a whole, that makes the latter absolutely unfit for many of the domestic or household uses to which it is put. In many instances, in fact, serious accident, impaired health and strength and even death, have been directly caused by, or traceable to, the use of water of an undesirable or non-potable quality.

Some of the impurities, nevertheless, which are to be found in natural waters do not by any means render it non-potable; in fact, some are often desirable in that they make the water more palatable for drinking, or, as is the case with our so-called mineral waters, impart to it some decided medicinal value. Others again simply give it some objectionable taste or odour or property, but do not render it unfit for the majority of farm uses, or make it unhealthful.

HOW WATER BECOMES IMPURE.

Pure natural water is an unknown thing except that which falls as rain toward the end of a very heavy shower. It is even doubtful if this latter is always absolutely chemically pure. The moment water comes into contact with the atmosphere near the surface of the earth, but more particularly with the soil and rocks, it begins to absorb the various impurities which it is afterwards found to contain. Because of its great and universal absorbent and solvent power it dissolves a certain proportion of some or all of the constituents of the soil and rocks and these dissolved portions are carried along in solution in the water wherever it goes unless, by some means or other, it is made to part with them. These dissolved substances frequently make water which we get in our wells or elsewhere, unfit for domestic use.

But even more dangerous and more objectionable are those impurtiies which find their way into our water supplies after they are located, such as dead and decomposed animals and plants, seepage from barnyards and out-houses, refuse from factories, sewage from towns and cities, and many things from other sources.

All these latter can, and should be prevented from gaining entrance, in most cases, by proper safeguards. If not prevented, when possible, their presence can only be regarded as a straight case of adulteration.

OBJECTIONABLE IMPURITIES.

Objectionable impurities, or those constituents whose presence is undesirable for various reasons, are of two classes, namely:

(*a*) Organic impurities.
(*b*) Inorganic impurities.

(*a*) Organic impurities, or in other words, the dead remains of plants and animals or their excretions, and the products of the decay of these, are the most dangerous ones with which water can be contaminated. Not only have these bodies the power, when taken into the alimentary tract of animals and men, to produce grave digestive and other disorders; but what is probably more important, their presence in water is a sure sign of the presence of numerous kinds of bacteria which feed upon them.

In addition to the above objections, the presence of organic matter in water very frequently discolours it and gives it a forbidding appearance; or imparts to it a bad odour or nasty taste. This is what happens when large quantities of raw sewage, barnyard drainage, or seepage from peaty swamps get into the water. Furthermore, such water is hard on utensils in which it is stored or boiled; causes frothing, incrustation and corrosion in steam boilers; and attacks destructively all metals with which it comes in contact.

DETECTION OF ORGANIC MATTER.

The presence of organic matter is not always made evident by the mere colour or odour or taste of the water—sometimes the clearest and brightest water, one that is palatable and sparkling, may be dangerously polluted. It is never wise, therefore, to depend upon appearance—a chemical examination should always be made. Such an examination in all its detail is not easy or simple, but useful information can be obtained by the following tests:

1. Pour half a pint of water to be tested into a wide-mouthed bottle or decanter which has been thoroughly washed and scalded with pure boiling water; close it with the palm of the hand, or better, with a glass stopper, and shake it violently up and down. If an offensive odour is then perceived on immediately removing the hand or stopper, the water is probably contaminated with sewage, or other forms of decaying or decayed organic matter.

2. To a little water in an absolutely clean glass vessel add a drop or two of sulphuric acid, and enough permanganate of potash solution to tinge it to a faint rose colour; cover the vessel with a saucer or glass plate and let stand. If the pink tinge is still visible after a quarter of an hour, the water is probably free of organic matter.

3. Pour a little solution of silver nitrate into a carefully cleaned and dry glass. See that it remains clear (if not, the glass is not properly cleaned); then pour in some of the water. Should a strong milkiness appear that is not cleared upon the addition of a little nitric acid, the water is probably contaminated with sewage. This test is not conclusive in proximity of salt wells or in the vicinity of the ocean where the water may be influenced by spray or seepage from the sea.

The above three tests are only useful for determining whether or not it is advisable to have a more elaborate or costly analysis made by a skilled chemist.

If the water is found to be contaminated with organic matter then an inspection should be made to find, if possible, the cause. Most organically impure waters are so because of some preventable factor, and if this be located and removed the water then becomes pure. It occasionally happens, however, that a water is bad because at some time or other before it reaches the point from which it is drawn by the user, it has to pass through some naturally infested location such as a swamp or some other place possessing a mass of dead and decaying organic matter. In such circumstances it is necessary to locate a source of supply elsewhere.

How to Purify a Water of Organic Matter.

If a water is not too badly infected with organic matter it can often be purified in small quantities, sufficiently to make it potable. On the large scale, however, it can only be economically handled by large corporations, such as cities or towns, or other governments.

One of the simplest methods of purification is to boil the water for a short time. This will kill bacteria, drive off bad odours due to any sewage gases that may be present, and render somewhat inert, physiologically, the small amount of partially decayed organic matter.

In case the water is coloured this treatment will not clear it up, if the colour is due entirely to organic matter (or to suspended particles of soil, iron, etc.). Under such circumstances, in addition to being boiled, the water would have to be passed through a filter composed of a considerable depth of alternate layers of good clean sharp sand, gravel and charcoal. This filter would have to be re-charged every day with fresh sand, gravel and charcoal, or with some of these that have been previously used and then afterwards thoroughly aerated and cleansed by spreading out in the sun or by baking in an oven.

Another method of purification is by the use of disinfectants. The most satisfactory disinfectant to use is chloride of lime, provided it is fresh and of good quality (33 per cent. available chlorine) and used in sufficient quantity. The method of using this substance is to be found on page 73 of this bulletin and need not be repeated here. This treatment gives the water an odour of chlorine at first, but this finally passes off on standing or can be removed quickly by boiling for a few minutes. It also destroys the colouring in the water (if the latter be due to organic matter and is not present in too large quantities), and thus makes it unnecessary to filter.

The best plan, in cases of organic impurity, however, is to remove the cause, if it can be found and is removable; or, as before stated, if the cause is not removable, to locate a new water supply.

(*b*) Inorganic impurities, or those derived from the mineral constituents of the soil and rocks, are seldom dangerous unless present in large quantity. Sometimes poisonous minerals are to be found in water such as lead and copper, and even iron, usually because of lead, copper or iron pipes, etc., through which the water has passed; sometimes sufficient mineral is present to give the water a decidedly salty or brackish taste, i.e., salt water and alkali water; but very seldom, under average conditions, does water contain sufficient mineral of any kind to make it unfit or objectionable for consumption by man or beast.

The chief objections to inorganic impurities are that the water is made "hard" by them and often quite unfit for cleansing, cooking some kinds of vegetables, laundry work, or boiler use; also useless for many industrial purposes, such as the retting of flax; and sometimes destructive to metal pump connections and other metal parts coming in contact with it for any length of time.

DETECTION OF HARDNESS.

The detection of hardness in water is a simple matter. Hard water does not form a lather readily with soap but, instead, produces a sticky, curdy substance which adheres to the hands or clothes washed in it with soap. Such water also turns milky when soap is put in it; and furthermore, usually forms a thick incrustation on the bottom and sides of vessels in which it is frequently boiled, such as a teakettle or boiler, or the flues of a steam engine. Also if the water is very hard, it is found that some kinds of vegetables, as beans and peas do not soften properly, but rather become harder and tougher and hence less easily digested, when cooked in such water.

REMOVAL OF HARDNESS.

Hard water, on a small scale, can often be somewhat remedied for domestic use by various treatments. To do this intelligently one should understand that hardness of water is of two kinds, namely:

(1) Temporary hardness.
(2) Permanent hardness.

Temporary hardness is caused mainly by the bicarbonates of calcium, magnesium and iron. This is the kind of hardness which causes a water to form a whitish scum on top when boiled for a short time, or which produces a sediment in the bottom, or on the sides, of a vessel after boiling for a short period.

This kind of hardness can, fortunately, be easily remedied. If a gallon of water be boiled until about a quart of it has boiled away, it will usually be found that it has lost all its temporary hardness; and if a water so treated had nothing but temporary hardness in it originally, straining now to remove the scum and sediment will give a water almost perfectly "soft."

Permanent hardness is a kind of hardness which is caused principally by the dissolved chlorides, nitrates and sulphates of calcium, magnesium and iron and can only be easily detected after the temporary hardness has been removed by boiling. If the water is still hard after boiling and straining, it is quite safe to conclude that it contains permanent hardness. Or if a water is hard, and on test is found not to contain temporary hardness, it is then safe to assume that its hardness is of the permanent variety.

There is no simple method for removing permanent hardness. The only way to remove it is to treat the water with some kind of chemical, such as washing soda or phosphate of sodium, and the amount of these chemicals to use can only be determined by a rather complex chemical analysis. However, boiling for a short time, after the addition of a small spoonful of either of these to two gallons of the water, will probably be about the average amount to use to remove the permanent hardness more or less completely from most waters. After this treatment straining will give a water practically soft.

Most hard waters have both kinds of hardness, particularly waters to be found in limestone formations or districts, or in districts containing rocks with considerable calcium in their makeup. Usually, in this case, the hardness is about equally divided between the two classes, sometimes one predominating, sometimes the other. In this case a combination of the boiling and chemical treatment will completely soften the water.

Many elaborate methods have been worked out and put into operation for softening water on the large scale. But these are only available to large industrial concerns that can employ a chemist to oversee the work or to constantly advise them. The farmer needing much soft water should aim at providing means for catching rain water and storing it in sufficient amount to supply his need.

Chemical Analysis Offered.

Anyone desiring chemical analysis of his water supply will be willingly aided in every way possible, through analysis, advice and otherwise, by application to the Department of Chemistry of the Ontario Agricultural College. Directions for taking and shipping samples of water to this laboratory will be found in Appendix 4, page 82. Forms of this Appendix will be supplied on application to the Department of Chemistry, O.A.C., Guelph.

THE SEPTIC TANK METHOD OF DISPOSING OF CHEESE FACTORY AND CREAMERY WASTE WATER.

BY FRANK HERNS, CHIEF DAIRY INSTRUCTOR, LONDON, ONTARIO.

The disposal of cheese factory and creamery wash water by the septic tank system presents, because of the special kind of solid content, greater difficulties than does the handling of house sewage. The fatty solids especially (which do not readily decompose) must be prevented from entering and clogging the tile.

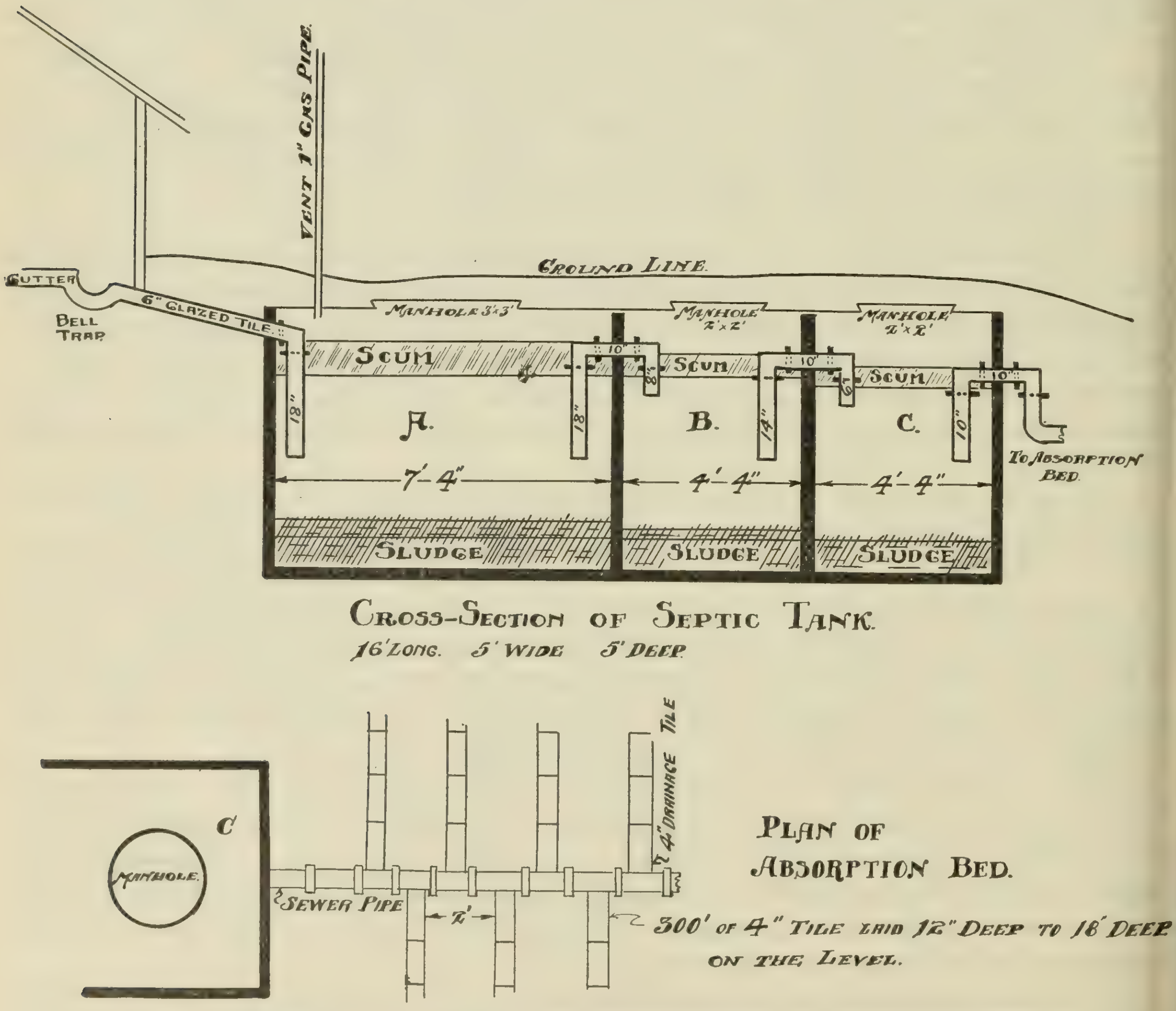


Fig. 64.—System for taking care of Cheese Factory and Creamery Waste

The tank should have at least three compartments through which the waste water must pass on the way to final absorption by the soil. With hard soil, a filter bed is necessary which may require special drainage, since an outlet for the surplus water not absorbed by the soil or taken up through evaporation must be provided.

The cement tank is so constructed as to retain most of the sediment and floating material in the first compartment. The additional chambers retain most of the organic matter and sediment which may pass over from the first section and thus prevent so far as possible anything but water from leaving the last compartment. Decomposition of the organic matter is encouraged through retention in the tank for as long a time as possible.

In the settling chambers, any material which will float rises to the top in the form of scum, while sand and some other sediment falls to the bottom. The tank must, therefore, be cleaned about once each season. The organic solids slowly decompose through bacterial action and since most of this material remains in the first section of the tank, it must be large enough to provide for an accumulation.

SIZE OF TANK.

The larger the tank the longer the sewage may be retained and the greater will be the decomposition of the organic matter before the liquid passes into the tile. There should be capacity sufficient to hold all of one day's washings in the small section C. A double partition cement tank, 16 feet long, 5 feet deep and 6 feet wide with 5-inch walls and 4-inch partitions, should be about the right size for the average factory.

CONSTRUCTION OF TANK.

Six-inch glazed tile, carefully laid, may be used to conduct the waste water from the factory to the tank. A bell trap is placed either in the factory gutter or near the factory to shut off the odour coming from the drain. At the point at which the water enters the tank it is desirable to attach an elbow with an arm (about 18 inches long), the lower end of which is always in the water below the scum. This prevents the breaking of the scum and undue mixing of the incoming sewage with that already in the tank—a matter of importance in successful operation. The tank should be covered with six or eight inches of soil and kept air-tight except where the vent (which may consist of a two-inch gas pipe properly stayed and extending beyond the top of the factory) is placed to carry off the foul gasses caused by the decomposition of the material within. An air inlet may be required at the discharge end of the tank to make the vent more effective. In order to afford communication of sections A, B and C with the vent, the two partitions should have at least one inch of space between the top and the cover of the tank.

For cleaning purposes a man-hole is left in the cover of each section, or the cover is so arranged that the different sections may be gotten at easily, especially the first and largest compartment.

The discharge pipes are placed at opposite ends of the partitions in the tank and may consist of special four-inch sewer fittings or be made of four-inch iron pipe with four-inch elbows.

The tank plan indicates the length of the discharge pipes required for withdrawing the water from section A and discharging into section B; from section B into section C and from section C into the tiles or drain. The discharge pipes in the partition between section B and C are placed four inches lower than those in the partition between section A and B, and similarly the discharge pipes from section C into the tile are placed four inches lower than those in the partition between section B and C.

For creameries it is well to lay one-and-a-half-inch gas pipe over the tank through which the pure water from the cream cooler and cream vats may be discharged directly into the drain. This water requires no purification and if conducted through the tank would necessitate one of too large dimensions and the large amount of cold water running into the tank might cool the contents too much for a rapid decomposition of the solids.

THE RECEIVING TILE AND ABSORPTION BED.

Four-inch tiles are laid level under twelve to eighteen inches of soil in rows two feet apart to receive the treated sewage from the tank and thus distribute it evenly over the ground area. The joints are left slightly apart and may be covered with pieces of tile or tar paper to prevent soil from falling into the joints. It will require about 300 tile to dispose of the water, although the number will depend on the amount of water that has to be disposed of and the condition of the ground. Sandy or gravelly soil will readily absorb water. Four-inch field tile will hold approximately one-half gallon each. Therefore 300 tile will be sufficient for about 150 gallons of water.

If the soil is stiff clay or not porous it will not readily absorb the water, in which case it will be necessary to construct a filter bed of sand and gravel to the depth of twelve to eighteen inches through which the tile is laid. An outlet through under-drainage of the filter bed for the surplus water will be neccessary.

A Few Points to be Remembered.

(*a*) Tank of sufficient capacity. For large factories increase the size of tank and absorption bed twenty-five per cent.

(*b*) At least three compartments.

(*c*) Prevention of fatty solids from leaving the tank and entering the tile.

(*d*) Sufficient tile, properly laid to dispose of the water.

(*e*) Under-drainage of clay soil and filter bed constructed.

APPENDIXES

Persons desiring information on any of the subjects mentioned below should apply for blank forms of these Appendixes to the Departments indicated, and fill them in to the best of their ability, and return. *There is no charge.*

APPENDIX I

(HYDRAULIC RAM)

(Apply to Department of Agricultural Engineering)

1. How many gallons per minute does the source of water supply?........................
   Spring or stream?...Yield?..
2. How much water per day is needed?..
3. How many feet fall can be secured?...
4. How high will the water have to be lifted above the ram?....................................
5. How far approximately between source and ram?...
   and ram and buildings?..
6. If ram be put 3 feet below surface, can the waste water be drained off?..............
7. Do you wish water supply for both house and barn?...
8. Submit a simple sketch of your premises, showing house, barns, water supply, lay of land, measurements, etc.

APPENDIX II

WATER SUPPLY SYSTEM

1. What is your source of water supply?..
2. If well, is it dug or drilled?...Is there plenty of water?
   ....How much lower would the water level be than the basement floor of the house or barn?..
   How far is well from house and barn?..
3. Will water be required for both house and barn and also for lawn service?
   ....
   What is the size of your family?...............................How much livestock is kept?...Is the house to be equipped with bathroom, kitchen and laundry fixtures?..
4. Have you a cistern?...................................What size is it?..............................
   Do you wish both hard and soft water "on tap"?..
5. How do you propose to do the pumping?...
   If by motor, state voltage A.D. or D.C. used?...
6. Describe your present pumping outfit and water system, if any, in order that we may be able to advise you if it can be made any use of in your new layout...
   ....
   ....
   ....
7. Send us a sketch of your buildings, with location of well and any other features that might aid us in laying out a water system for your place.......................
   ....

APPENDIX III

Directions for Taking a Sample of Well Water for Bacterial Analysis

(Apply to Bacteriological Department)

1. It is essential that the bottle to contain the sample and also the cork stopper for the same be sterilized by boiling in water 30 minutes.

   Care should be taken not to touch the neck of the bottle nor that part of the cork that goes into the bottle with the hands, or anything that has not been just previously sterilized.

   A small bottle, as a medicine bottle, will hold sufficient for the test.

   Note.—A sterile bottle, in a mailing case, ready for taking the sample, will be forwarded on application to the Bacteriological Department, O.A.C., Guelph.

2. Pump for one or two minutes, or until all local laterals are emptied of water that has been standing in them.

3. In removing the cork from the bottle do not touch the part of the cork that goes into the neck of the bottle against anything, and do not remove cork until ready to take the sample.

4. Do not touch the mouth of the bottle with the hands or anything else.

5. Let the water from the pump run directly into the bottle, then cork tightly with the same cork that is removed from the bottle, place the bottle in the mailing case, stamp the case and mail it immediately to the Bacteriological Department, O.A.C., Guelph.

6. Write a card stating date and time of day the sample was taken.

APPENDIX IV

Directions for Taking a Sample of Water for Chemical Analysis

(Apply to Chemistry Department)

Container.—A bottle of not less than one quart capacity is to be used, preferably one with a glass stopper. If there is no glass stopper, the bottle must be stopped with a new cork.

Preparation.—The bottle must be thoroughly cleaned, all foreign substances removed, and scalded out with boiling hot water and then allowed to drain until cool.

Taking of Sample.—If the sample is to be taken from a well, the water must be pumped out for about five minutes, or long enough to empty all pump connections before the sample is taken; if from a tap, the water must be allowed to run to waste for about ten minutes, or long enough to empty all local laterals, before sampling. If the sample is to be taken from a lake or stream, it must be taken some distance from the shore, the sampling vessel being plunged a foot and a half below the surface, to avoid the surface scum. Samples are not to be taken immediately after a storm.

From wherever the sample is taken, the bottle must be rinsed out several times with the water to be analysed. The bottle must not be filled quite full, a small space must be left for the expansion of the water. Cork, and tie a piece of cloth over the neck to keep the cork in place. Do not use sealing wax.

NOTIFICATION.—Send notice by mail stating by what express company you are sending the water, and the date of the shipment. Also give, as fully as possible, the history of the well or source of the water, and remarks on the sanitary surroundings. Address the package to Chemical Department, Ontario Agricultural College, and prepay express charges on the same.

APPENDIX V

INFORMATION RE WELLS

(Apply to Agricultural Engineering Department)

Persons enquiring about wells, either from the standpoint of construction, improvement, bacteriological analysis or chemical analysis, should send the following information on form to be had on application to the proper Department.

WELL:

1. Distance to rock.. 2. Depth of well....................................
3. Nature of soil (gravel, clay, sand or loam)..
4. Whether the well is fed by a spring..
5. The mode of construction of the well, including its wall and covering.............
6. Is the cover tight?...
7. Depth of water in the well...
8. Whether the appearance or depth of the water is affected by heavy rains........
9. Date of digging................................ 10. Date of last cleaning..........................
11. Any indications of pollution, discoloration of sides, etc..
12. Amount of water used from well..

SURROUNDINGS:

1. Proximity to dwellings, outbuildings, stables, drains, sewers, etc......................
2. Drainage of surrounding soil: Is slope towards or away from well?..................
3. Is surface drainage from house or barns to or away from well?.......................
4. Are surroundings clean?..

WATER:

1. Has the water been healthful?...
2. Have there been any cases of typhoid fever?...
   If so, how many in last five years?...

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BULLETIN 331] [DECEMBER, 1927.

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

Public Speaking and Debate

By G. H. Unwin, B.A., B.S.A., Associate Professor in English

AND

E. C. McLean, M.A., Lecturer in English

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INTRODUCTION

Rhetoric—in its original sense, "the use of language (either written or spoken) to produce a desired impression"—is an ancient and honourable art. Among the Greeks, orators were held in the highest esteem, and even the fighting men of Homer, such as Achilles, Menelaus, and Ulysses, are constantly referred to as "speakers of words as well as doers of deeds." From the time of Aristotle to the present, the study of oratory has been one of the recognized branches of learning. It is true that the invention of printing and the multiplication of books and newspapers diminished the influence of the orator for a time; but with the growth of the democratic idea, free speech gained a new importance, and now public speaking is everywhere considered a necessary part of education.

There has been, however, a considerable change in platform methods, a change noticeable within the lifetime of the present generation. The tendency among the most effective speakers of to-day is to avoid the flowery style. The oratorical type of speech, with its appeal to emotion, its rolling periods and its frequent gestures, is passing. With the increase of general education audiences are more particular about the material of speeches. They ask for clear exposition and logical argument, and they like to see the direct application of what is said. It is not that the emotional appeal is neglected, but rather that the practical and educational value of public speaking has increased. Modern conditions have reduced the opportunities of the old style orator, but have multiplied those of the speaker on every-day topics.

Public speaking is indeed a valuable training for all young people. It teaches them to express themselves no matter where they may be, and enables them to exert an influence in community life. It cultivates clear and specific thinking and the ability to profit by what one reads and hears. Moreover, the practice of public speaking has a great social value in bringing people together and cultivating talent. This is a branch of education which entails no particular expense. It combines instruction and amusement and is of direct, practical use in later life. One cannot too strongly urge the boys and girls of city and country to take advantage of their opportunities in this kind of work.

This bulletin is written chiefly for the use of people intending to practise public speaking. The writers have found, in their experience with many classes, that most of the bad habits of the platform can be traced to a wrong first conception of what public speaking is, and have therefore laid stress on the nature of speech and the principles which govern it. The first part deals with general principles, and the second shows how different kinds of addresses may be built up. At the end there is a section on debating.

WHAT IS PUBLIC SPEAKING?

The very idea of making a speech in public—even before a very small audience of friends and acquaintances—is enough to make some of us alarmed. If asked to make a speech, we possibly reply, "Oh, no, I couldn't think of it; I've never done anything like that in my life." If we refuse in such terms as that, we are not telling the exact truth, however sincere we may be; for we are showing that we do not know what public speaking really is.

Though we have never yet made a speech, we have all done something very similar—and done it practically every day of our lives. We have talked to other people, sometimes to one or two, and sometimes to half a dozen at once

when we monopolized the conversation for a few minutes to tell some interesting news. Suppose we put together a dozen of these people that we have talked to many times already. There is an audience. Suppose we have heard some important piece of news that will take us, say, three to five minutes to tell . . . Well, there we are making a short public speech. Is there anything in that so very alarming?

PUBLIC SPEAKING IS NOT RECITATION

On first thought a speech may seem more like that well remembered ordeal of our schooldays—a recitation, and therefore to be dreaded as an unusual sort of task. It does resemble the recitation in two respects: 1. In the speech, as in the recitation, one person does all the speaking. 2. The material and, in some cases, the exact wording of the speech have been previously prepared.

But if we recall some of our early attempts at recitation, we will readily see that the likeness between them and the successful speech cannot extend further. The school boy generally recites without thinking of the meaning or feeling the importance of what he is saying, often indeed without understanding the words he utters. In Macaulay's well known poem "Horatius" there are a few lines which have often proved a stumbling block to the student who has been asked to memorize them. As Macaulay tells of the safe return of two of the gallant three over the bridge which is just about to fall, he writes:

> Back darted Spurius Lartius;
> Herminius darted back;
> And, as they passed, beneath their feet
> They felt the timbers crack.

Every teacher is familiar with the pupil who disregards punctuation and common sense alike and insists on repeating that third line in one breath—"And as they passed beneath their feet"! If those Romans really did that, they must have been, not only valiant soldiers, but remarkable acrobats.

The difficulty lies in the fact that *the reciter is thinking of the words and trying to recall them, and with all his attention directed to that, he cannot think of the meaning too.* He has prepared all his words, but he has not prepared the thought and feeling which should accompany them.

PUBLIC SPEAKING RESEMBLES CONVERSATION

In conversation, on the other hand, we may occasionally have to pause to find the exact word to explain what we have in mind, for in this case thought and feeling come first and determine the words we use. For that reason our conversation never has the lifeless, monotonous tone that we too often hear in recitations. Instead the speaker's voice changes in tone quite naturally. If he becomes eager and excited, he speaks more loudly and more quickly. If he is pondering some difficult problem, he speaks more slowly, and his very tones suggest deliberation. If he has good news to tell, he speaks quickly and eagerly; if bad news, he speaks slowly and hesitatingly. When he asks a question, his voice rises in pitch; when he gives a command or expresses unalterable conviction, the tone of voice does fully as much to convey his meaning as the actual words he uses. *Intelligent, animated conversation is always living speech;* that is, it varies continually in tone and in inflection. It is, therefore, easy to listen to.

In this respect the successful speech must resemble conversation most closely. It must at all costs avoid that dead level, monotonous tone which makes it almost impossible, no matter how interesting the subject, for an audience to listen for any length of time. *To be successful the speech must have the living language of conversation.* And since we are all accustomed to use this every time we talk, in making a speech we are not so much called upon to attempt something new, strange, and difficult as merely to repeat, under slightly different circumstances, something we all do easily and naturally every day of our lives.

There is another point that helps to make our speech interesting in ordinary conversation and that aids in giving it that living tone. It is our consciousness that people are responding to what we say. We do not speak merely to hear ourselves talk (at least, we trust we don't), but rather because we are interested in our listeners and desire to communicate with them. Unconsciously we watch for the appreciative smile when we tell a humourous story or for the look of interest or suspense as we narrate some unusual or thrilling incident. Such signs assure us that we are holding the attention of our hearers. To talk for any length of time to people who do not respond by word or look is most difficult.

This feeling of active communication between the speaker and his hearers is just as necessary in public speaking as in conversation. It is not manifested by questions and remarks as it often is in conversation, but it is there just the same, and it may be detected by the expression on the faces of the audience and by the continued attention the audience gives. When it is absent we feel that we are talking against a stone wall from which all that we say falls back without making any impression. But when it is present, when we feel that we are speaking to people who respond to our thoughts and feelings, we are stimulated to do our very best.

Public speaking, then, is very much like ordinary conversation in two important points:

1. The speaker's words express something that he is thinking and feeling at the time he speaks.
2. The speaker has the sense that he is in active communication with his hearers, that is, that they are responding to what he says.

These are far more important aspects of public speaking than its resemblance to our elementary attempts at recitation.

PRINCIPLES OF PUBLIC SPEAKING

Some would-be speakers worry a great deal when the time comes to deliver their speeches, but are not sufficiently worried about preparation to spend more than two or three hours on that. *In order to make a good speech it is, first of all, necessary to have something to say worth saying.* Thorough preparation is the only way to make sure of that; furthermore, it is one of the best possible means of avoiding stage-fright at the last minute.

The Extempore Method

The best method for the beginner to practise is what is known as the extempore method. This method demands careful preparation of material but prohibits any exact memorization or any reading from manuscript. The material

is carefully collected and arranged, and the whole speech may be written out as the speaker would like to deliver it. But at that point the speaker discards his manuscript and practises delivery with but brief notes before him to recall the various sections of the speech.

The chief advantage of extemporaneous speaking is that in this kind of speech it is much easier to establish and maintain that feeling of active communication between speaker and audience which is the very life-blood of a successful speech. Without its presence running throughout, the body of the speech, no matter how well chosen the speaker's words may be, will remain cold and lifeless.

Why has the extempore speech this advantage? First, because if the speaker reads his address, the manuscript itself forms a barrier between speaker and audience which neither can entirely forget. Second, because if the speaker recites a memorized speech he must recall an exact set of words and phrases and in so doing, unless the process has become purely instinctive, his attention is concentrated on words, not on the ideas and emotions which the words represent. The result is that the words and the words alone are communicated; the speaker is using dead language and his delivery seems cold and mechanical.

The extempore is by no means a lazy man's method, and the speaker's first attempts may be more difficult than if memorization were allowed. It is worth while, however, to learn from the very beginning *to talk* to an audience and to avoid reading or reciting. Practice is this method will give a feeling of freedom and ease in speaking which the beginner can obtain by no other method.

CHOOSING A SUBJECT

The choice of a subject is not an easy matter, not because of a lack of good subjects, but because of the difficulty of selecting *one.* If compelled to make your own selection you may find it of some assistance to *think over* the following suggestions as possible sources of a subject:

1. Personal experience, especially the unusual sort of experience.
2. The events of the day as presented in the news and editorial columns of newspapers and periodicals, *e.g.*, Lindbergh's flight might suggest a speech telling of recent advances in aviation or possibly a speech telling of the first crossing of the Atlantic by a steamship.
3. Articles of special interest in magazines or books, *e.g.*, articles telling of new discoveries or inventions either of general interest or of special importance to the farmer.
4. Topics of conversation on which you have noticed that people express differences of opinion.
5. Other matters of provincial, national, or international interest.

Choose a subject which is likely to interest your audience and one on which you have or can obtain sufficient information for a speech that will be worth while.

If you are a beginner the best sort of subject to choose is one in which you have more experience or direct first-hand knowledge than the majority of your audience. If you have taken a trip on a harvest excursion, or spent a winter in a lumber camp, or done some prospecting in northern Ontario, or spent some time in a large automobile factory, you have in any one of those experiences suitable material for a short speech. Subject matter that comes from your own experience is apt to be presented more vividly than subject matter derived solely from reading.

MAKING A PLAN

If you are to speak on a subject that you are not at all familiar with, it may be impossible to draw up a plan until you have acquired a considerable amount of information. As soon as possible, however, a tentative plan should be made out. A plan helps to collect and define the rather vague and hazy first ideas which one has upon a new subject. Without an outline of some sort you are likely to waste much time and effort in collecting material that will be of no use.

In making out your first plan, review what you already know of the subject and write down possible headings under which the material might be placed. Look through your headings, combine those that are closely related, eliminate the unimportant, and arrange what remains in the simplest logical order.

This preliminary plan should be regarded as purely tentative and should be open to change repeatedly as fresh information on the subject reveals a possibility of bettering it The planning of the speech is a process, not a single act, and it should not be regarded as completed till all your material has been assembled. Then, and then only, you are ready to draw up your final plan in the assurance that you are making the best possible use of the material in hand.

LIMITING THE SUBJECT

The length of time that you are to speak will necessarily limit the amount of material in your speech. Don't try to exhaust the subject; long before you do this you will have exhausted your audience. To begin with, do not undertake to make speeches of more than five or ten minutes. Only the really good speaker should be allowed to talk for more than ten minutes at a time.

Although you have decided that you will make but a short speech, you nay find when you begin to make your preliminary plan or outline that the ubject you are intending to speak on is a broad one and that there are many ossible headings to consider. Suppose, for example, that you have decided o speak on Radio. Radio is new enough and remarkable enough to interest lmost everyone; so the subject seems a good one. Thinking over possible eadings you might write down:

1. History of Radio.
2. How it works—the general principles.
3. Kinds of transmitting stations.
4. Kinds of receiving sets.
5. How to install and care for a receiving set.
6. The widespread use of radio at present.
7. Its value for entertainment.
8. Its values for business and other purposes.
9. A forecast of future uses.

You will see, on looking over the list, that the subject is a very broad one. your speech were to last a week, you might be able to deal fully with all these spects; but since your time is limited, you must limit the subject accordingly. is best to choose one or two headings from such a list and develop them fully, eglecting the others entirely. This will leave room for illustrations and for fficient detail to make the speech worth while. The superficial survey of ch a broad subject is generally much less interesting than a full account of me limited aspect.

What headings should you choose to speak on? That depends entirely on the object of the speech. If your purpose is to convince people that it is worth while to own a radio set, you might speak chiefly on its values for entertainment, business, and other purposes. If you wish to impress them with the importance of radio, you could mention briefly its widespread use at present and the short time that it has been in use, and then deal more fully with its present values and possible future uses. If you wish to give some information of value to those who own or intend to own radio sets, you might speak on the kinds of receiving sets, and how to install and care for a set.

From this example we see that *to make a successful speech*, not only must you choose a subject, but *you must also decide what the object or purpose of your speech is. Having decided that, you must limit the subject and select the material you are to use in accordance with your purpose.*

COLLECTING MATERIAL

After reviewing what you already know of the subject and making out a tentative plan, you are ready to begin the search for material. Material on the subject may be gathered by reading and by conversation. If you can get in touch with some one who knows the subject well, he may be able to give you many valuable hints and to suggest what you should read. Do not expect anyone, however, to do the work of planning and preparing the speech; that is your task. Others can help you best by assisting in the collection of material and possibly by criticizing your preliminary plan. If you have access to a library where there is a good encyclopedia, such as the *Britannica* or *Americana*, you may begin with that. You will find that the encyclopedia not only gives authoritative information, but also in many instances gives references to other sources of material.* A library may also have on file recent numbers of newspapers and magazines which are the chief sources of information for current events and questions of the day. If the library has an *International Index to Periodicals* or *Readers' Guide to Periodical Literature*, you will find it an easy matter to turn up information from periodicals for the past twenty years. Statistical material may be found in government blue books and such year books as the *Canadian Annual Review* and the *Statesman's Year Book*. On many subjects the Extension Department of the Ontario Agricultural College is prepared to send out information. If you have not a good library at hand, you should write to them as early as possible.

Perhaps the most satisfactory method of collecting material is to use small cards about three by five or four by six inches in size or slips of fairly stiff paper cut to the same size. Each item of material, as it is found, can then be entered on a separate card, and the cards easily arranged afterwards in the order determined by your preliminary plan. If you carry around a few blank cards in your pocket, you will always be ready to make note of any new idea that comes to you or of any material you discover. The advantage of using the cards is that if at any time you wish to change the plan of your speech, all that is necessary in order to rearrange your material is to reshuffle the cards. New material may be at once put in its proper place without disturbing that previously collected, and at a moment's notice you can have all your material before you in

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*If in consulting the encyclopedia you fail to find an article on the required subject, turn to the index volume. References to many subjects which do not appear under separate headings are given there. Look also for any words you can think of that mean almost the same as the subject you have in mind. For example, if you fail to find Radio, look for Broadcasting, Wireless, etc.

any order you wish to consider adopting. To separate the various sections of your speech it may be well to insert special cards, each having written on it the heading for one section.

Once one has become accustomed to it the use of the card system means a saving in time. If to the beginner it seems rather cumbersome, he may prefer a small loose-leaf notebook which can be used in much the same way. A third plan is to use an ordinary notebook and write the main headings clearly, at intervals of several pages. Then each fact or idea gathered may be noted down under its appropriate heading. The advantage of this method is that the general shape or structure of the speech is always before the mind; it is, however, not so convenient as the card system if the plan of the speech has to be changed.

Whatever the method of collecting material some discrimination must be used in determining what to write down. A speech should not be made up of a series of extended quotations from the material that has been studied in preparation. Avoid copying down verbatim long extracts. It is much better to try to summarize what is of use to you as you go along and get the gist of the matter down in your own words. Material taken from encyclopedias and other books of reference is likely to be rather dull and should be used sparingly. To make the "dry facts" less dry, appropriate illustrations and anecdotes, if possible, from your own experience, may be introduced.

ARRANGING MATERIAL

During the time that you are collecting material you should be arranging it in accordance with your preliminary plan and making changes in this plan when you see any possibility of improvements. When, at last, you have all your material together, you are ready to consider its final arrangement.

Sometimes the nature of the material is such as to determine your arrangement; in such cases you are forced to follow what may be called a logical order. For example, if you are telling how to build a barn, you would start with the foundation and work up, not with the roof and work down.

In all other cases you follow what might be called a psychological order. That is, you consider the tastes and interests of your audience and choose from a variety of possible arrangements the one most likely to gain and hold their attention. Some time should be spent in considering the possibilities of arrangement. If you have used the card system in collecting material, it will be easy not only to outline on a separate sheet of paper the various possibilities, but actually to arrange all your material in the several ways which may seem desirable. After doing this it should be much easier to decide on the most suitable plan.

TESTING THE ARRANGEMENT

The varying nature of the subject matter, the purpose of the speaker, and the type of audience to be addressed all affect the arrangement and make it mpossible to lay down any general rules. There are, however, certain tests which may be applied to almost any type of arrangement. Unless there is good reason to the contrary, your arrangement should meet these tests.

Central Idea Test

(*a*) Quite near the beginning of the speech make clear to the audience what your subject is and what you propose to do with it.[*] If the subject is a complicated one it may be well to outline in advance the plan you propose to follow in dealing with it.

(*b*) See that the greater part of your speech is devoted to the development of this announced subject and do not allow minor issues to take up much of your time.

(*c*) Make clear to the audience the connection of the various parts of your speech, both to each other and to the general subject of your address.

(*d*) See that your material is so arranged and developed that it will be impossible for anyone who has half listened to you to go away afterward and say he did not known what you were talking about.

Beginning and End Test

(*a*) Plan the beginning with the aim of arousing interest in your subject; introduce the subject in such a way that the audience will wish to hear more about it.

(*b*) Plan the conclusion to emphasize the most important idea in your whole speech.

(*c*) Make the first and last section of your speech such that a person who had heard only those would know at least what you had aimed to accomplish.

WRITING THE SPEECH

Some experienced speakers may find that in preparing to speak they need to do little or no writing beyond jotting down a few headings and possibly a set of figures to which they may wish to refer. On the other hand, many speakers with years of experience still find it advisable to write out the whole speech. It is impossible to say that one method is right and the other wrong, but for the beginner writing is recommended.

Although you have made copious notes in collecting your material, the speech you are to deliver is bound to seem very vague until it is actually before you in black and white. You know then just what you are doing with your material, and you are far better able to revise and criticize both style and arrangement. Furthermore, the very act of writing out what you intend to say serves to impress it on your mind so that it is much more easily recalled. You will not remember exactly what you have written, but you will have much less trouble in expressing yourself orally than if you had not previously expressed the material in writing.

Write out the whole speech just as you would like to deliver it. If you have used cards or slips in collecting material, you will now find it easy to keep before you the material needed for each succeeding section of the speech. Consider carefully what you have written and make any last improvements you can in style or in the beginning and conclusion. Some speakers find it advisable to write the beginning of the speech last of all since they can then be more certain what will make an effective introduction.

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[*] This does not mean that the speech should be begun with a formal statement, "My subject to-night is so and so and my purpose on speaking on it is thus and thus". The subject may be announced formally; the purpose should usually be implied indirectly. On some occasions to begin with an open announcement of purpose would defeat the whole object of the speech.

PREPARING PLATFORM NOTES

You are now ready to prepare notes to speak from. Many people feel that to be most effective the speaker should address his audience without showing or glancing at notes or manuscript. On some occasions, such as in delivering brief after-dinner speeches when an appearance of freedom and spontaneity aids greatly in giving the right atmosphere, it is well to get on without notes if one can. But on other occasions when the material to be dealt with may be complex and when it is important to omit nothing and to present all in the order planned, it is wiser for most speakers to use notes.

Your notes should consist of headings which will readily recall to you each section or each paragraph of your speech. Do not copy whole sentences which you may be tempted to read from the notes. *Put down headings only, so that you will be forced to speak, not read.* Quotations that you wish to read out or sets of figures may, if brief, be copied in full in their appropriate place. If very long they may be copied out on a separate card or sheet of paper. Make your notes legible. The light may be poor on the platform where you speak, and a mere glance at the notes should suffice to give you what you need from them at any time.

Avoid equally the use of notes made out on large sheets of paper or on slips of postage stamp size. The former are extremely obvious, difficult to manipulate, and the audience may feel the large sheets get between them and the speaker. The latter are easily misplaced, difficult to read, and frequently give the impression that you are trying to conceal the fact that you are using notes. If you use notes, use them openly, but unobtrusively. Small cards or slips of paper, such as were used in collecting material, are best.

PRACTISING THE SPEECH

The manuscript should now be put away and not referred to again. Force yourself to talk through the whole speech, using the notes to keep your arrangement as planned. If you remember the words you have written down previously, use them; but when you fail to recall them, do not refer to the written manuscript. Express the idea in a new set of words and get through the whole speech. *Practise in this way as frequently as possible, not trying to retain the exact wording of the manuscript so long as you get some suitable wording for your ideas. This is the most important step in the preparation of your speech.* No matter how good your material, poor delivery will ruin its effectiveness. See that the writing of your speech is completed in time to allow you at least two or three days for practice of this sort.

The beginning and the end are the most important parts of the speech and should be prepared and practised the most carefully. Some speakers like to memorize them while giving the rest of the speech extempore, but such a plan is not generally to be recommended.

DELIVERING THE SPEECH

When a grouchy old lawyer was once asked by a young speaker for some advice on delivery, he rather testily replied "Stand up! Speak up! Shut up!" This reply touches on the three points of major importance, but perhaps the beginner might appreciate a little more detailed advice.

Getting Started

Before beginning to speak you should take up a position close to the front of the platform and as near the middle as possible. Don't be in too great a hurry to begin lest some of the audience fail to hear your first words. If people are shifting position or exchanging comments, pause a moment till you see that you have their attention. Begin by addressing the chair and your audience. Then announce your subject in such a way that everyone will hear you. It is a good plan to select some one near the rear who seems to be attentive and interested and address your opening remarks directly to him. You can tell by the expression of his face whether or not he is hearing you; make him hear easily and the rest of the audience also will hear you.

Face the Music

Most important of all, in beginning and throughout the speech, talk to the audience, not to a window on one side, or to the first row of empty seats, or to your own toes. Even though at first it may seem hard to face the concentrated attention of several dozen pairs of eyes, look your audience in the face. Without doing that you can never speak effectively. In private life we distrust the man who refuses to meet our eyes. On the public platform we demand that any man who would hold our attention must look at us, not at the ceiling or the floor. It is difficult at first, but will seem less so if you remember that you are speaking before people whose attitude is not hostile, but friendly. An audience always sympathizes with the speaker in his first attempt and admires the one who, in spite of his nervousness, gets through his speech successfully. The audience is working with you and for you, not against you. Their obvious interest and enjoyment, once you have learned to look for it, will be a great encouragement and will help you to put more of yourself into the speech.

Make Yourself Heard

Not only in beginning the speech, but throughout, take care to make yourself easily heard. Remember to watch your friend in the back seat and see that he continues to hear easily. Some speakers who begin well soon drop their voices to a low monotone and never succeed in breaking away from it. An audience will not listen to one whose voice is so weak that they must strain to catch every word. Give the material that your have prepared a fair chance by making it as easy as possible for people to listen. Speaking too loudly is a fault, but it is a fault found in few beginners. Speak up!

Take Your Time

Don't talk as if you were being paid for your efforts in accordance with the number of words per minute that you can utter. Give the audience time to grasp the significance of what you say. In reading, if one misses a point, one can go back and read over the doubtful passage. In listening to a speaker there is no chance to pick up a point once missed. See that each idea is understood as you present it, and do not be too anxious to hurry on to the next idea. If your time is near an end and you have much left to say, leave out some parts entirely and deliver what you do present effectively. A few beginners need to be advised to speed up rather than to go slowly. Such slowness is usually the result of inadequate preparation, and the best way to remedy it is by more practice in delivering the speech before attempting it in public.

Avoid Monotony

Next to inaudibility the greatest of sins in a speaker is monotony. *Some variety is essential for a continued interest in almost any phase of human activity.* Even sports and games lose much of their appeal when the luck or ability is all on one side and the result always the same. Monotony may be of two sorts—monotony of tone and monotony of pace. The best remedy for both is to acquire that feeling, so often spoken of in this bulletin, of being in active communication with your audience. Just as long as you are trying to talk off into space a certain amount of previously prepared material, you are likely to be monotonous. As soon as you begin to look at your audience and to take an interest in their reaction to your words, you are on the way to a varied and interesting type of delivery.

Another aid in avoiding monotony is to make sure that you give proper emphasis to your spoken words. To bring out the meaning of almost any sentence you speak, it is necessary to emphasize some words more than others. This emphasis may come from the tone of your voice, the speed at which you speak, or from a break in your regular pace of speaking, that is from a pause. Variation in tone alone may serve to give half a dozen different interpretations to such a simple group of words as "He is going to town." We illustrate only the three simplest:

(*a*) Simple statement—He is going to town.
(*b*) Determination that he must go—He *is* going to town.
(*c*) Question—He is going to town?

The pace at which you speak should not remain uniform throughout your speech. Less important matters may be passed over comparatively quickly, but you should go more slowly in sections that are of great importance or in sections where the material is unusually complex.

The proper use of pauses is a further valuable method of securing emphasis and of giving variation to your speech. A pause serves to recall the attention of the audience and to concentrate it on what immediately follows. A pause after a striking statement or a question gives the audience time to consider it before you give your own commentary or answer. If the statement or question comes at the end of a section as the climax, a pause should be made before beginning the next section. Meaningless pauses should be avoided. The peaker who indulges in them loses his power to gain emphasis by a pause roperly placed. Avoid particularly the habit of pausing at the end of every hree or four words you utter, quite regardless of the meaning and grammatical tructure of the sentence you are delivering. Pause, rather, before you begin he sentence till you have your idea clearly in mind. Then you will be able to make the pauses come at points where there is a natural pause in the meaning structure of the sentence.

Avoid addressing all your remarks to the same section of the audience. Don't watch that man in the middle back seat all the time. Look about you nd pick out several of the most interested looking people in different parts of he audience. As you continue your speech, look now at one and now at another y so doing you not only vary your manner, but you also make people in all rts of the audience feel that you are talking directly to them.

Avoid Slovenly Speech

Some of us in our ordinary conversation are very careless as to the use of oper English. We make mistakes in grammar when we really know better, use commonplace worn-out slang phrases, and we mispronounce or slur over ny of our words. In speaking in public we should be more careful, since a

mistake made from the platform sounds much worse than one made in private conversation. The best way to prepare to speak clearly and correctly in public is to try to do so as much as possible in private.

Avoid "Running Down"

Some speakers who do well with the greater part of their speeches seem to allow the conclusion to fade out in feebleness. The effect is somewhat like an alarm clock that is running down and giving a last few irregular strokes. You have prepared your speech with the idea that the conclusion will be an important part of it. Your delivery must give emphasis to this material; otherwise it will fall flat. Avoid acting as if you yourself had grown tired of the subject or were anxious to get to the end of an ordeal. Above all, don't leave you place at the middle front of the platform until you are entirely finished with your speech. Nothing can give a worse impression than to see some one gradually talking himself to the edge of the platform and ending his speech just as he steps off.

Gesture and Movement; Good or Bad?

The elaborate system of gestures for which directions are given in some books on public speaking belongs with the memorized speech and the oratorical type of delivery. The aim of this bulletin is to advocate a style of speaking much more simple, direct, and business-like. In regard to gesture the personality of the speaker must settle the matter. Some good speakers use no gestures at all; the majority, perhaps, use them to a certain extent. A French orator speaks with his whole body; the Anglo-Saxon is likely to be less demonstrative. Most speakers will possibly find that after they become accustomed to speaking in public they are inclined to develop a few gestures. If such movements are easy and natural and are used to emphasize the speaker's words, they may add to the effectiveness of the speech. If forced and artificial, or if of such a nature as to attract attention to themselves, they may hinder rather than help. The speaker who uses gesture in private conversation will possibly never do his best on the platform without the use of gesture. Another type of speaker might do much better by avoiding it entirely. Each must find out his own best method of procedure. The extremes of both types are bad. Avoid standing with such rigidity that you might be mistaken for a speaking statue; avoid also whirling your arms about like a windmill.

Movements which do not serve to emphasize the speaker's remarks should be avoided. The buttoning and unbuttoning of one's coat, the thrusting of hands into pockets, the meaningless stroll up and down the platform, the nervous shifting of weight from one foot to the other—all tend to distract the attention of the audience. The beginner is apt to indulge in some of these movements without knowing that he does it. He should have some friend, who will report to him afterwards, on hand to watch for such errors when he is delivering his speech. By being thus warned of his defects, he may be able to avoid them in his next attempt.

Be Grateful for Criticism

A last word on delivery. Both in practice and after the delivery of your speech try to get the advice and criticism of some one who knows what good public speaking is. Purely destructive criticism is discouraging, but the friend who can point out your faults in a kindly fashion is doing you a much greater service than the people who tell you that your speech was splendid and have nothing more to say about it. Without such criticism you will never discover many faults that are quite obvious to the audience.

TYPES OF SPEECH ILLUSTRATED

We have chosen the following types for illustration: I. Informative speech. II. Narrative or descriptive speech. III. Speech persuading to action. IV. Speech of introduction. V. After-dinner speech. Each of these types requires a particular method of approach, based partly on the material and partly on the kind of audience for which it is prepared.

I. The Informative Speech

The main object here is to give a clear explanation. You may have to show the construction of a piece of machinery, to give directions as to how some work is to be done, or even to explain some abstract idea. It is to be presumed that your audience is anxious to learn something rather than to be amused, and therefore you should concentrate your energy upon getting as clear and logical an arrangement as possible. Here are some subjects for this kind of address:

Dramatics for Rural Sections.
Installing a Radio Set.
Methods (or Advantages) of Tree-Planting.
Labour Savers for the Housewife.
The Importance of Pure-Bred Stock.
Forests and Water Supply.
Woman's Opportunity in Agriculture.

The introduction should contain one or all of the following: (*a*) A definition f the subject; (*b*) a reference to its timeliness or importance; (*c*) an illustration rom actual experience. For example, in beginning a speech on "Radio" you an refer to its educational value and to the number of farms now equipped ith radio sets; and if you intend to go into some detail it is a great help to he audience to state the main divisions of your speech in the introduction. n effective beginning for an address on "Forests and Water Supply" is given n the following anecdote, an illustration from experience:

> "Mr. Chairman, etc.
>
> Mr. Ozark Ripley tells the following story. When he was in Timagimi district he happened to be smoking a cigarette by the water's edge when he noticed a small Indian boy looking at him very closely. Thinking that the boy was wanting a smoke, he dropped the stub on a rock and sauntered away. The young Indian ran quickly to the spot and jumped on the cigarette with both feet, afterwards lifting water from the lake in his cupped hands and taking every possible precaution to put out the sparks. Mr. Ripley, astonished and, if the truth be told, a little ashamed, asked him why he did this. In answer the boy pointed to the forest and said: "Me save father of waters," etc., etc.

n illustrative anecdote is one of the best of introductions, as it gives the dience the central idea of the speech in tabloid form.

Developing the Body of the Speech

The first step in preparing material is to decide upon your main headings d the order in which you will take them up. With some subjects, such as nstalling Radio," this presents no particular difficulty. In others, such as orests and Water Supply," the problem is a little more complicated. You ve to make people understand something they cannot actually see, namely, e relation between forests and water supply. As we think over the subject, e following leading questions suggest themselves: What happens to rivers d streams when the surrounding trees are removed? How does this take ce? How can we prevent it? These three questions provide a framerk on which to build the speech. The next point to consider is whether

these are in their most effective order. The first makes people realize the importance of the subject, the second gives them the details while their interest is fresh, and the third suggests a practical application. The original order is clearly the right one.

Having this general scheme in your mind you start collecting material, as explained in an earlier part of the bulletin (p. 8), and when the whole speech has been composed you make skeleton notes for use on the platform (see p. 11, Preparing Platform Notes). The notes for the address on "Forests and Water Supply" will be something like this:

I. What happens to water supply when the forests go?
  (*a*) Rivers overflow in spring—cause much damage.
    E.g., Quebec floods of 1924—thousands of dollars lost.
      Forest denudation in St. Lawrence basin.
      Also report in daily papers, July 1st, 1926—Roumania, Tcheko Slovakia.
    E.g., Quote Julian Smith in "Forest and Outdoors": "Well forested watersheds are an *insurance* against flood damage."
  (*b*) Rivers dry up in summer.
      Quote from various articles.
    E.g., In India and China—there are desert areas which were once fruitful valleys before timber was all cut.
      In Canada, Muskoka District—and many burnt over sections in the North Country.
  (*c*) Scientists say there is *less rainfall.*
    E.g., In Russian Journal of Forestry—experiments conducted—showing that rain storms are drawn to wooded areas. (Liesnoi Journal, St. Petersburg, Vol. 41.)
    E.g., Also prairie conditions, etc.
  (*d*) Precipitation is lost.
      Forest retains moisture from rain and snow. *Enlargc this point.*

II. How does this take place?
  (*a*) Vegetation, roots, etc., act as *sponge*—make flow uniform, avoid *freshets* in spring and drought in summer.
  (*b*) Forests make best use of moisture of precipitation.
    Snow remains longer . . .
    Forest soil does not freeze so deeply—thus surface water is absorbed, etc.

III. How can we prevent it?
  (*b*) By planting trees where possible.
  (*b*) By guarding against forest fires.
  (*c*) By encouraging forestry work.
      etc., etc.

To show how these platform notes are used, we shall take one main heading and expand it as would be done in the actual delivery of the speech.

I. "The first question to be considered is: What happens to our water supply when the forests go? (Pause.) Actually, there is no less water running through the river-beds after the removal of the surrounding trees. The various bodies of water passing onward to the Great Lakes or the seas are as great, in the aggregate, in regions which have been denuded of timber, as they were

before the trees were removed. In the aggregate, I say, they are as great. Wherein does the difference lie, then? (Pause.) It lies not in the quantity but in the quality of the flow. In forested areas the flow of water is comparatively slow and uniform; it can be depended upon and used to advantage. In unforested areas, on the other hand, it is sometimes too slight, and at other times too abundant.

"Let us consider, then, what happens to rivers and streams when the timber is removed either by fire or wasteful cutting.

"(*a*) (Note: Rivers overflow in spring, cause much damage.)

"In the spring the streams are swollen by melting snows and turned into rushing torrents. When the banks are furnished with a protecting carpet of roots and vegetation this flow is naturally retarded and kept within bounds. Moreover, in forested regions, as will be explained later, the snow itself does not melt so quickly as it does in open country, and much of its water is absorbed by the surface soil before it can reach the stream to swell the flood. Now, when the protecting carpet is removed, by fire or other agencies, the torrent has free play. It scours out the river-bed to the bare rock, and turns it into a kind of funnel where the water rushes ever faster and faster, carrying loss and destruction to the inhabited valleys below. (Illustrations.) It is estimated that the disastrous Quebec floods of 1924, in which thousands of dollars worth of property were swept away, were largely due to the heavy lumbering which had been carried on along the St. Lawrence tributaries. To use a more recent illustration —On the editorial page of the *Mail and Empire*, July 1st, 1926, we read of destructive floods in Roumania and Czecho-Slovakia, attributed chiefly to the fact that these countries, since the war, have been forced to cut and sell most of the timber from their highlands and watersheds.

"(Summary of point made.) Forests do not prevent floods, but they control them more effectively than any number of artificial dams. Mr. Julien Smith, of the Hydro-Electric Commission, says:

" 'Well forested watersheds are an insurance against flood damage.' "

Conclusion: The ending of the informative speech will of course vary with the subject and the audience. Thus the demonstration of radio will require no special conclusion. The other type of speech will probably contain some central idea, which may be enforced in a concluding sentence. The reader is referred to the introductory part of this bulletin for suggestions on concluding speeches.

II. Narrative or Descriptive Speech

The main object in a speech of this type is to interest or amuse the audience. Information is given, it is true, and explanations, but these are of general rather than practical interest. This is the kind of speech which one may be called upon to make before a literary society or reading club. It may be a speech of personal reminiscence, relating one's own experiences, or it may take the form of a sketch of some well-known character in history or literature, or even the discussion of some book. Here are some subjects:

Picturesque Northern Ontario.
The Romance of Oil.
The Story of the Hudson's Bay Company.
William Henry Drummond.
John Masefield.
Sam Slick.
The Joys of Farming.

Introduction.—The introduction should be quite informal. One may use an amusing story, or a quotation, or one may turn to profit a remark made by some previous speaker, if opportunity offers. In the sketch on a character in literature or history, an effective introduction can be made by giving in a sentence or two some fact which will sum up his personality. For example, a talk on Sam Slick might be prefaced in the following manner:

"Sam Slick—or, to give him his proper name, Judge Haliburton—has been called 'a statesman in motley.' His character was a strange mixture of thoughtfulness and serious purpose on the one hand, and jovial, careless humour on the other. He had a serious message for his day and generation, but in order to deliver it he put on the jester's cap and bells. The sayings of Sam Slick, the shrewd yankee pedlar, are full of mature wisdom. This character which Haliburton created and which in return made him immortal, is the ancestor of all the village philosophers who have since taught the world by making it laugh."

In "The Romance of Oil" the following rather striking contrast may be used:

"Sixty or seventy years ago fuel oil was a waste product. In 1859, Colonel Drake, while sinking a well for brine, was hampered by the large quantities of petroleum which flooded his workings. Realizing its possible value he began to put it into barrels, and in a short time it became the important product, and gave to the place its name—Oil Creek, Pennsylvania. Since then oil has become one of the necessities of modern industry. It has, moreover, provided the English language with a new phrase, 'to strike oil,' or, as defined in Webster, to make a lucky hit financially."

There is not any great difference between the introduction of the second and that of the first type of speech. In general, the narrative or descriptive speech requires an introduction which will put the audience at their ease, whereas the informative speech requires one that will set them thinking; but within this general range there are many variations. Each subject has its own problem for the speaker.

Developing the Body of the Speech

The suggestions given under Type I apply in a general sense to this kind of speech also. There is this difference in the method of attack, that whereas in the informative speech clearness and logical order are all-important, in the second there is another equally vital purpose, namely, the giving of pleasure. For this reason one should steer clear of detailed explanations, lists of dates, or figures and statistics, which are generally dry, particularly to people who are on pleasure bent. There is a Spanish phrase which runs: "Mix useful with agreeable." This is not a bad precept to follow in the preparation of any speech, but it applies particularly to the kind we are discussing. A biographical sketch is frequently very dull, consisting of a lifeless catalogue of dates and facts; on the other hand it may be made most interesting, if these facts are varied with personal and human touches, revealing the character of the man and enabling the audience to recreate him as a living human being. Here are some headings for the speech on "Sam Slick":

I. Sam Slick is an international character.
    Belongs to all countries—like Don Quixote, Pickwick, etc.
    Number of editions of book—125 at least.
    Fame on the continent, etc.

II. Life of Haliburton.
    Early years.
    His failure as a politician—Reasons.
    Friendship with Joe Howe and doings of "The Club."
    Last years in England.
III. Appearance and personality.
IV. Quotations from Sam Slick.
V. Why the book has survived.

"The Romance of Oil" furnishes an interesting narrative for a speech. You could first describe the finding of oil, then mention the various stages of its development, and finally its importance in modern life. This subject can, of course, also be treated as an informative speech.

The first subject on the list, "Picturesque Northern Ontario," makes a good illustrated lecture. Slides may be hired, at a nominal rent, from the Provincial Picture Bureau, 46 Richmond Street West, Toronto. There is a fine selection of slides on various subjects—British and Canadian history, nature study, science, agriculture and general topics.

Conclusion.—In this kind of speech one should never attempt to summarize what has been said. Anything like a formal summary destroys the effect of the speech at once. It is necessary, however, to "round off" your speech and to leave a good final impression. The most effective ending is a restatement, in one or two sentences, of the most important fact in your story.

III. THE SPEECH PERSUADING TO ACTION

Persuasion seems to be the peculiar province of the speaker. The salesman interviewing a "prospect," the lecturer conducting an agricultural campaign, the member of parliament addressing his constituents, the lawyer defending his client, the minister exhorting his congregation, are all speaking in order to persuade to action—or to belief which will result in action. There are two kinds of persuasion: one that calls for direct action; the other that seeks to *convince* people of some truth. One cannot always separate or define these two kinds of persuasion. It will suffice, however, to have the reader understand that in this section we are treating of speeches which persuade, directly or indirectly, to action, whereas in the section on debating those forms of speech are covered, the aim of which is chiefly to convince.

One may find plenty of material for study on the editorial pages of the newspapers. The reader is also referred to the lists of subjects already given, which may be easily adapted to speeches of persuasion. Thus "The Advantages of Tree Planting" may be made a direct appeal to farmers to plant trees wherever possible. The speech on Northern Ontario might be given the title "Go North, Young Man, Go North!" and so on. We give one or two subjects as illustrations of the third type:

Why a Young Farmer should go to an Agricultural College.
A Community Hall should be Built in this Section.
A Speech Recommending the Formation of a Reading Club.
A Plea for Co-operation among Farmers.
A Nursing Service for Country Districts.

SKETCHING A PLAN OF ATTACK

When a man wishes to persuade a number of people to do something—or to convince them of the necessity of doing it—he must consider the psychology of his audience and plan his attack accordingly. In order to move his hearers to action he must appeal to the emotions or desires which are likely to be strongest in their minds. Such compelling motives are too many and too varied to be even enumerated here; we can merely take some of the commonest motives for illustrations. These are: (1) The desire for financial improvement; (2) the desire for social improvement; (3) the sense of responsibility; (4) sympathy. In preparing a speech on this sort of topic, it is a good plan to ask yourself which of these motives is likely to be strongest in your audience. Suppose, for the sake of example, that you are trying to interest a group of young farmers in the Agricultural College. If your audience is composed chiefly of young men you will emphasize the first two motives, the desire for financial and for social improvement; on the other hand, if your audience has a large proportion of the older men and the fathers of families, the last two motives will be equally strong.

We will suppose that you are to have an audience composed chiefly of young farmers and that you are going to concentrate on the first two motives. You now collect as strong a proof as you can, in the shape of facts, figures, the testimony of others, etc. Your outline will be something like this:

A course at the Agricultural College will be profitable to you in many ways.

(I) It will help you to farm more profitably.
    Farming has become a science—new problems, new methods, new machinery, changed conditions, etc., etc.
    A course at an agricultural college shows one where to get the latest information and how to use it.
        Illustrations—Testimony of college graduates who are farming.

(II) It will give you more varied interests in life.
    The social activities of a college are a training in organization, etc.
    This training will not only make your own life more interesting but will benefit the whole community.
        Egs.—Dramatics and literary societies—agricultural clubs, athletics—Y.M.C.A., etc., etc.

(III) It will provide you with another means of livelihood.
    Should conditions force you to leave the farm, you can earn a living and still keep in touch with agriculture.
        Illustrations—Many men who have started in professional agriculture and are now farming. Quote actual cases.

(IV) Education is becoming more and more necessary for every kind of occupation.
    Proof—Refer to the increasing numbers of technical schools all over the world—the overcrowding of schools and colleges—the large equipments and grants of money, etc., etc. Quote educationists.
        "Every calling has become a study in itself."

(V) The agricultural college gives you the kind of education you need, comparatively cheaply.
    Proof—Costs of courses, board, etc.—compare to other universities.

t will be seen that in this plan the motives which would have the most direct nd practical appeal to the farm boy are placed in the most effective positions— rst and last.

Let us now consider the other topics briefly. The person advocating the uilding of a community hall should, of course, be well posted on the costs of the ndertaking, up-keep, running expenses, etc. He should be ready with sug- estions as to the ways in which the hall might be useful and should have, if ossible, some plans of suitable buildings. All these details constitute his uxiliary forces. His appeal, however, will be directed to one or other of the mpelling motives. What are they in this case? The desire for social im- rovement, for one. The sense of responsibility also, of which community irit is only a special form. It is for the speaker himself to decide which of ese will be the main; and which the secondary motive.

In advocating the forming of a Reading Club we shall appeal to the second otive, the desire for social improvement; but it is quite obvious that the main otive will be the desire for culture, or intellectual improvement, a very powerful ipulse with many people, and one quite separate and distinct from the desire r social improvement.

In speaking on Co-operation one appeals first to the desire for financial in and secondly to the third motive, responsibility for the community; whereas the last, the whole speech would be based on two motives, responsibility and mpathy, with the last probably the dominant motive.

IV. The Occasional Speech

By this we mean a speech delivered on some special occasion. Such dis- rses are as varied as the occasions which call them forth. They may be emn and impressive, as in the dedication of a church or the erection of a nument, they may be informative, as in a speech introducing some great n whose work is not known to the general public, or they may be amusing in the best after-dinner speeches. On the whole, however, the purpose of h speeches is either to impress or to entertain.

We may omit any discussion of speeches of dedication since only experienced akers will be called upon to make them. We shall, however, say something ut the speech of introduction and the after-dinner speech.

Speech of Introduction

It usually falls to the lot of the chairman to introduce speakers who are ing part in the programme. The speech of introduction is not easy. While ould be brief, the words which are said must be appropriate to the occasion must accomplish their purpose. There are three essentials: First, that visiting speaker be made to feel at ease; second, that the audience be told ething about him and his work; third, that they be prepared for the subject which he is to speak. We mention these in what is probably the order of r importance. For the success of the evening it is absolutely necessary to the speaker, particularly if he is not known to the audience, all the encour- nent that one can. A gloomy or bored chairman can, with a few well-chosen ls, dry up the springs of inspiration in the most well-intentioned speaker. refore, we place this as the first essential, that the speech of introduction ain some simple and genuine expression of welcome to the speaker. With ct to the second essential, the chairman should be warned in plenty of

time, so that he can find out something about the speaker. If at all possible, the chairman and speaker should meet beforehand and become acquainted. Let us emphasize the necessity of having the chairman posted on the necessary details. He must not say much, but what he does say must create a bond of sympathy and understanding between speaker and audience; otherwise he had better say nothing.

We mentioned a third requisite, namely, that the introductory speech should prepare the audience for the topic on which the address is to be given. As a rule it will be sufficient to state clearly the subject of the speech. The explanations will be given by the speaker himself. Let us avoid the mistake of the chairman who laboriously read up the subject and in a long introductory address succeeded in stealing the best of the speaker's "ammunition" and effectually spoiling his speech. After all, the function of the chairman is not to display his own knowledge but to enable others to display theirs.

V. THE AFTER-DINNER SPEECH

This type of speech is one that presents great difficulties for most people. Even with considerable experience it is not always easy. An after-dinner speech should be spontaneous, that is, it should not show too careful preparation; it should be easy and witty, and yet contain some point, it should seem to spring naturally out of the mood of the moment and the occasion. There are some gifted people who can make a speech answering all these requirements and make it, too, with very slight preparation, but most of us are not so constituted. We require a fairly definite plan of attack and must spend some time beforehand thinking over what we are going to say. In order to help people in this situation we give a few suggestions as to the shape into which an after-dinner speech may be cast:

(1) The opening remarks should be timely and original. In beginning, the speaker may refer to the reason for giving the banquet, or he may tell a story which suits the occasion. A favourite introduction is a humorous reference to the speaker's feelings on rising. We quote a good example of such a reference, made on one occasion by Lord Justice Bowen:

"There is one moment in the career of the prophet Daniel which at such times as this I am always inclined to envy. In the lion's den he had the consolation of knowing that when the great banquet was over it was not he who would have to return thanks."

Humorists have made fun of the introductory story, but, after all, it is the sort of thing that people like to listen to after a heavy dinner. An appropriate anecdote which is fairly new breaks the ice more effectually than anything else.

(2) The speech should contain a point, that is to say, it should be built around some central idea that is worthy of reflection. A mere series of unconnected stories becomes very wearisome. The central thought, however, should not be too profound; in a word, not such as to impair the digestion of the audience. Moreover, it should on no account deal with any controversial matter. Mr. Sydney F. Wicks has laid down the maxim that in an after-dinner peech "there should never be more than one point, one quotation, one story." He adds that there should never be less than one point.

(3) The speech should contain references to experiences which are common to all. There is nothing which puts an audience into a better frame of mind than allusions to experiences which they recognize as their own.

(4) The speech should have a neat and clear-cut ending. The termination is important in any address, but especially so in an after-dinner speech. It is good strategy to determine exactly what your closing remark will be and, having made it, to sit down forthwith.

We print a speech of Samuel L. Clemens (Mark Twain), at a dinner given by the Army of the Tennessee at Chicago, Ill., in 1877 in honour of General Grant. This speech is conversational and witty and leaves with us the impression of ease and spontaneity. Yet if the reader cares to examine it closely he will find that it answers all the requirements laid down above. In the first place the speaker's remarks are particularly timely and breathe the very spirit of the occasion; secondly, there is a central idea running through the speech the real importance of babies); thirdly, the allusions to experiences are particularly happy; and finally, the ending is both graceful and effective. On this occasion, of course, Mark Twain was the speaker of the evening, and his address was considerably longer than the usual after-dinner speech.

The Babies

Mr. Chairman and Gentlemen: "The Babies." Now, that's something ke. We haven't all had the good fortune to be ladies; we have not all been enerals, or poets, or statesmen; but when the toast works down to the babies, e stand on common ground—for we've all been babies. (Laughter). It is a ame that for a thousand years the world's banquets have utterly ignored the aby, as if he didn't amount to anything! If you, gentlemen, will stop and ink a minute—if you will go back fifty or a hundred years, to your early arried life, and recontemplate your first baby—you will remember that he mounted to a good deal—and even something over. (Laughter).

You soldiers all know that when that little fellow arrived at family headuarters, you had to hand in your resignation. He took entire command. ou became his lackey, his mere bodyguard; and you had to stand around. e was not a commander who made allowances for the time, distance, weather, o anything else. You had to execute his order whether it was possible or not. And there was only one form of marching in his manual of tactics, and that was the double-quick. (Laughter). He treated you with every sort of insolence and disrespect, and the bravest of you did not dare to say a word. You could face the death-storm of Donelson and Vicksburg, and give back blow for blow, but when he clawed your whiskers and pulled your hair, and twisted your nose, you had to take it. (Laughter). When the thunders of war sounded in your ears, you set your faces towards the batteries and advanced with steady tread; but when he turned on the terrors of his war-whoop (laughter) you advanced in—the other direction, and mighty glad of the chance, too. When he cried for soothing syrup, did you venture to throw out any remarks about certain services unbecoming to an officer and a gentleman? No; you got up and got it! If he ordered his pap bottle, and it wasn't warm, did you talk back? No you; you went to work and warmed it. You even descended so far in your menial office as to take a suck at that warm, insipid stuff yourself, to see if it was right—three parts water to one of milk, a touch of sugar to modify h colic, and a drop of peppermint to kill those immortal hiccoughs. I can ae that stuff yet! (Laughter).

And how many things you learned as you went along! Sentimental young ols still take stock in that beautiful old saying, that when baby smiles in his lep it is because the angels are whispering to him. Very pretty, but "too

thin"—simply wind on the stomach, my friends. (Laughter). If the baby proposed to take a walk at his usual hour—half past two in the morning—didn't you rise up promptly and remark (with a mental attitude which wouldn't improve a Sunday school much) that that was the very thing you were about to propose to yourself? Oh, you were under good discipline. And so you went fluttering up and down the room in your "undress uniform" (laughter); you not only prattled undignified baby-talk, but even tuned up your martial voices and tried to sing "Rock-a-Bye Baby on the Tree-top," for instance. What a spectacle for an Army of the Tennessee! And what an affliction for the neighbours, too, for it isn't everybody within a mile around that likes military music at three o'clock in the morning. (Laughter). And when you had been keeping this thing up two or three hours, and your little velvet-head intimated that nothing suited him like exercise and noise, and proposed to fight it out on that line if it took all night—"Go on." What did you do? You simply went on till you dropped in the last ditch! (Laughter).

I like the idea that a baby doesn't amount to anything! Why, one baby is just a house and a front yard full by itself; one baby can furnish more business than you and your whole interior department can attend to; he is enterprising, irrepressible, brimful of lawless activities. Do what you please you can't make him stay on the reservation. Sufficient unto the day is one baby. As long as you are in your right mind don't ever pray for twins. Twins amount to a permanent riot; and there ain't any real difference between triplets and insurrections. (Great laughter).

Among the three or four million cradles now rocking in the land there are some which this nation would preserve for ages as sacred things, if we could know which ones they are. For in one of these cradles the unconscious Farragut of the future is at this moment teething. Think of it! and putting a word of dead earnest, unarticulated, but justifiable, profanity over it, too; in another, the future renowned astronomer is blinking at the shining Milky Way with but a languid interest, poor little chap, and wondering what has become of that other one they call the wet-nurse; in another, the future great historian is lying, and doubtless he will continue to lie until his earthly mission is ended; in another, the future president is busying himself with no profounder problem of state than what the mischief has become of his hair so early (laughter); and in a mighty array of other cradles there are now some sixty thousand future office-seekers getting ready to furnish him occasion to grapple with that same old problem a second time! And in still one more cradle, somewhere under the flag, the future illustrious commander-in-chief of the American armies is so ittle burdened with his approaching grandeurs and responsibilities as to be giving his whole strategic mind, at this moment, to trying to find out some way to get his own big toe into his mouth, an achievement which (meaning no disrespect) the illustrious guest of this evening also turned his attention to some fifty-six years ago! And if the child is but the prophecy of the man, there are mighty few will doubt that he succeeded. (Laughter and prolonged applause).

DEBATING

Debating is a Specialized Form of Speech

The problem of the debater is essentially different from that of the person preparing a speech or address. In the latter the object is to impress, to interest, or to convince an audience; the speaker may presume that the majority of his hearers will accept what he says in a fairly impartial frame of mind. The debater, on the other hand, must reckon with an active and watchful opposition. Every statement he makes must be strongly supported; moreover, he must know both sides of the question and must prepare for counter arguments. The failure to realize this is responsible for the number of debates which are not really contests in any sense, but merely consist of four speeches, perhaps well prepared and delivered, but having very few points of contact. It is the element of struggle that gives a debate its special interest.

Debating is particularly good training in that it accustoms us to look at a question from all sides, to refrain from making wild statements unsupported by fact, and to work with others.

Preparation of the Brief of a Debate

The brief of a debate is an outline of the *whole question*. Some debaters prepare very elaborate briefs, containing all the possible arguments on both sides, all available references in the way of favourable or unfavourable evidence and a bibliography of books and articles on the subject. This takes more time than can usually be given to the subject; we mention it, however, in order to show the essential purpose of the brief which is, to enable the debaters to take a bird's eye view of all the arguments and then to select those which are really essential and which will give them the strongest case. While we do not recommend the preparation of elaborate briefs, some such preliminary survey of the whole subject is absolutely necessary. We, therefore, give a statement of what the brief should contain, viz.:—(i) An Introduction; (ii) The Main Body of the Speech; (iii) Conclusion.

I.—*An Introduction.*

This should include:

(a) A brief statement showing the importance of the question.
(b) An explanation of the Resolution and Definition of Terms.
(c) A statement of the issues.

In certain topics, which are unfamiliar to the audience a thorough explanation is necessary. Thus in the Inter-University Debate of 1926 the following was debated by nine colleges:—"Resolved that a system of Proportional Representation should be adopted in Canada." It is obvious that the average person knows very little about Proportional Representation and, moreover, is unaware that it is a vital issue in Canada. It was therefore part of the debaters' task to explain this system and tell them where it had been tried. In a more familiar question, say the subject of Oriental Immigration, or the old favourite, Capital Punishment, very little explanation would be required.

The *issues* are the main divisions of the argument. Anybody recommending a measure will have a number of reasons for so doing, perhaps eight or ten. On examining these he will perceive that they can be grouped under two, three or four general heads. The experienced debater will immediately sort out his reasons and arrange them under these main heads. The inexperienced person will leave them in the haphazard order in which they first occurred, and his arguments will be ineffective in consequence.

For instance, suppose we are debating the question that there should be reduction of Oriental immigration to Canada—we jot down roughly certain reasons as they come into our mind.

(1) The Oriental cannot be assimilated. (2) He complicates the labour problem. (3) He has lower standards of living than the white man. (4) He has a different standard of morality. (5) Australia has excluded the Oriental. (6) The United States has practically excluded him. (7) The Oriental is a very serious problem in British Columbia. (8) The Oriental saves his money and takes it home with him.

On looking these over it will be seen that we can group them under the following general heads which will be the main issues:

The Oriental is not likely to become a Canadian citizen.
(1), (3), (4), (8).
He makes it harder for Canadians to live.
(2), (3), (7).
Other countries have excluded Orientals.
(5), (6).

The statement of issues is extremely important. On it the whole argument rests. The affirmative side has the privilege of choosing the issues, or in other words picking the ground for the battle; the negative, however, may introduce other issues if they can prove that they are really important. For example, in the question on Oriental Immigration, the negative might introduce another issue—viz.: "that discrimiuation against any race is unfair." It will not be necessary to fix all the issues definitely until the subject has been fairly well prepared. The debater will find, however, that unless he first determines the general line of his argument, he will waste a lot of time thinking and talking over relatively unimportant points.

II.—*Main Body of the Speech.*

In some works on debating use is made of the term "clash of arguments." In the main body of the brief the arguments on both sides should be written down, and it will help the debater considerably if he can tabulate them so that each supporting argument can be considered with its possible answer. To illustrate this we give a table outlining certain arguments pro and con. The question we have selected for illustration deals with the export of unmanufactured pulpwood. We might word our resolution as follows:

> Resolved that all export of unmanufactured pulpwood from Canada should be prohibited by law.

In our introduction we show the size of the pulpwood industry and the importance of the question. We may then arrange our headings on a large sheet of paper in the form given below. We assume that the affirmative is preparing the brief.

Affirmative	*Negative*
We recommend an embargo on unmanufactured pulpwood for the following reasons:	
1. Our supply must be conserved. (See Frank D. Barnjum and Herbert J. Hodgins in Saturday Night and McLeans, etc.)	1. Amount exported is very small, about 10 per cent. of cut or 2 per cent. of total lost each year. (Report of Canadian Pulpwood Assc., Mail & Empire, Ap. 4 1925.)
2. Such a measure would increase the Canadian pulp and paper industry to the extent of at least $150,000,000. (Ref. Report of Royal Commission on Pulpwood, Canada, 1924.)	2. (a) It would aid the big manufacturer and put the small operator out of business. (b) Class legislation.
3. It would give employment to a large number of people in Canada.	3. (a) It would interfere with private rights of woodlot owners and settlers. (b) Would deprive settlers of their only *cash crop*.
4. It would bring in American capital.	4. This is hypothetical. The American paper manufacturer has other resources available.
5. It would enable us to control more effectively the various factors which bring about depletion of natural resources. (a) Forest fires. (b) Floods, etc.	5. To answer this argument the negative would have to give figures as to percentage of risk from slash, etc., and show that the risk from fire would not be materially lessened.

There is ample material on this question, which is an important one for Canada. If the reader wishes to work it up he might follow this general scheme, which includes most of the main lines of argument on both sides. We have given some references, but of course there are many more available for use under each heading.

The debaters will now be able to divide the material between them and each member of the team will work up the detailed proof of the part assigned to him. In the next section we give a plan of attack for each speaker, and the working out of the detailed proof will be given in this section (III. ii). The reader will readily see the advantage of preparing an outline of the whole case. For instance, let us suppose that he is the supporter of the affirmative. He concentrates upon his own particular part of the debate, but at the same time he can assist his leader with any information that may be of use in the first part of the affirmative case. Moreover, he has a clear idea of the arguments that may be brought against him and can prepare to answer them. The members of each team should work together and their two speeches should form one strong, coherent, and logical argument.

III.—*Conclusion. This will be a re-statement of the important arguments.*

A PLAN OF ATTACK FOR THE INDIVIDUAL SPEAKERS

A.—*Leader of the Affirmative.*

(i) *Introduction.* The aim of the introduction is to arouse the interest of the audience. Begin your speech with a few words showing the timeliness and importance of the question.

(ii) *Interpretation or Definition.* Read the resolution. Make clear the interpretation of the question as understood by the affirmative side. Define any words which seem ambiguous.

(iii) *Stating the Issues.* In any resolution there are two or more main issues, on which the proof depends. State and explain these as compactly and clearly as possible. The audience is then in a position to follow the detailed argument.

(iv) Developing the First Issue (or the First Two). The three points mentioned above are preparatory to your proof. Do not spent more than half your time (at most) on them. Begin, then, your proof of the first issue and cover the points assigned to you in the plan arranged by your team. (The method of developing proof is given under C.)

(v) *Conclusion.* Your conclusion should serve to emphasize that you have proved conclusively one (or more) of the main issues. It should not be a mere recapitulation of headings.

B.—*Leader of the Negative.*

(i) *Interpretation and Statement of Issues.* If the affirmative interpretation of the question and statement of the chief issues is fair and just, accept it without quibble. If you wish to dispute any point give sound proof that you are justified in a different interpretation. In a well-worded debate there should be little occasion for any dispute; but if the resolution really is ambiguous, or if some of its terms are, your whole case may stand or fall upon the proof you bring to support your interpretation. In the event of the affirmative having neglected any important issues, bring these forward.

(ii) *Developing the Case for the Negative.* The negative case may be developed by direct disproof of the affirmative arguments and by counter-arguments. (See IV, second negative.) The negative speakers have prepared certain lines of argument to disprove the general proposition. These will probably answer some of the arguments advanced by the affirmative, but not necessarily the most important. Attack those points in the affirmative argument which are fundamentally weak. If this must be done extempore use one of the following methods:

(a) Refute the points at the beginning of the speech, and then give the prepared argument—the easier but less effective method.

(b) Incorporate them in the body of the prepared speech; i.e., take them up in connection with the prepared arguments. This is the more difficult method, but is very effective when well carried out.

ILLUSTRATION OF A METHOD OF REFUTING

The speaker is dealing with the first issue:—that an embargo is necessary in order to conserve our supply of raw pulpwood.

"The leader of the affirmative recommends the embargo as a measure of conservation. We maintain that its effect would be very small, in fact almost negligible—in conserving our supplies. What are the actual figures?

In the first place, practically all our forestry experts are agreed that of the annual destruction and loss to our forests, 90 per cent. is caused by 'bugs, fungi, fire and wind.' My authority for this statement is a speech made by Ralph P. Bell, President of the Canadian Pulpwood Association. These agencies account for nine-tenths of the annual depletion of our timber. There is left—one-tenth to be accounted for by cutting both for lumber and pulpwood—both for lumber and pulpwood, note that please!

How much of this 10 per cent. is cut for lumber? Figures quoted from the same speech give the proportion for lumber as 8.4 per cent. of the total. For pulpwood the total is 1.6 per cent. of annual loss.

That is not all—of this 1.6 per cent. only one-quarter is exported—or let us be generous and say one-third. This when related to the total depletion, works out at about .5 per cent.—or one-two hundredth of the total!

The affirmative speakers are therefore advocating as a measure of *national conservation*, an embargo which can affect at the outside less than one-fiftieth of the annual loss of pulpwood—and of the total depletion of timber less than one-two hundredth."

Note.—In handling figures, give exact amounts when quoting but in summing up conclusions give them in the form which is easiest to grasp.

(iii) *General Policy of the Negative Leader.* It is not necessary to combat all issues. Admit those which the affirmative can prove easily, and concentrate your attack on the weakest of the essential issues. It is not necessary to outline your case as fully as the affirmative has done. If a counter-argument is to be used it may generally be left for the second speaker unless the first affirmative has given you nothing to attack. (See D, note).

C.—*Supporter of the Affirmative.*

(i) *Refuting the First Negative Speech.* Refute any attack upon vital points in your case. If the negative have not endangered your main issues, show this very briefly and proceed with the affirmative case. If you hope to win the debate you must complete it at all costs.

ILLUSTRATION OF AFFIRMATIVE COUNTER-REFUTATION

If the affirmative have these figures well in hand they may keep them for a counter blow. (See back, B. ii. illustration.)

"The negative's figures are misleading. Only 10 per cent. of forest lands have been alienated from the Crown and therefore come into the question of export. True—but these comprise the choicest parts. Edward Beck, Secretary of Canadian Pulp and Paper Association, estimates that this despised 10 per cent. of forest lands contains 60 per cent. of Canada's marketable and accessible pulpwood. Thus, the one-two hundredth proportion advanced by the negative is incorrect, and their figures do not weaken our argument.

(ii) *Developing the Main Issues in Detail.* Link up your speech with that of the first speaker by restating what he has established. Then proceed with the argument thus: State the topic of each argument in a short emphatic sentence. Restate to make clearer or more emphatic then proceed to the proof. Proof may be developed by the introduction of evidence, or by a process of reasoning (logical proof) or both together. Evidence consists of facts gained by experience, observation and reading, and of quotations from authorities. Use authorities where necessary, but do not quote too much, for long quotations spoil a good argument. In bringing evidence and quoting authorities it is important to show the relation of these to the point at issue. A fact is of no use unless its bearing on the argument is clearly shown.

ILLUSTRATION OF DETAILED PROOF

We claim that the embargo on raw pulpwood is a necessary measure of conservation. (Topic sentence.) Our wood resources are dwindling very rapidly and consequently all methods of conservation must be seriously considered. (Restatement). Some people claim that there is no cause for alarm, but the evidence available shows that there is reason for real anxiety on the subject. In the government estimates, where the stand has been given at five cords per acre, these same areas are now actually cutting out one cord to one cord and a quarter per acre. In Ontario a whole watershed, previously estimated as containing seven and a half billion feet, was recently re-cruised and the astonishing fact was revealed that it now contains only one and one-half billion feet. There are many other examples equally striking. (Here give others............) Our authority for these figures is................ (Evidence and authority.)

Since this enormous waste is going on, it is necessary to use every measure we can for conserving our natural supply. The cutting of pulpwood constitutes (logical proof) a considerable drain on our supply of accessible timber. The amount exported varies between 25 per cent. and 40 per cent. of the amount consumed. No matter what figures our opponents may bring to disprove this point, we maintain that the embargo would constitute a considerable saving of our timber resources.

(iii) *The Summary.* This should reaffirm the issues established by the affirmative side and show that they have been proved conclusively. It should not be a mere repetition of the headings of the speech, but should give the substance of the argument in highly condensed and emphatic form.

D.—*Supporter of the Negative.*

The full affirmative case is now before you. Bring any support you can to arguments of your colleague which have been attacked, then concentrate your efforts upon an attempt to disprove what you now know to be the weakest of the fundamental issues of the affirmative case. Deal with any other issues for which you have time. If counter-argument is to be used allow plenty of time to present it.

(i) *Methods of Rebuttal.* There are several ways in which an opponent's arguments can be weakened or overthrown

(a) By showing his evidence to be insufficient, unreliable, or irrelevant.
(b) By producing other evidence to outweigh that of the opponents.
(c) By showing that the proposition is unreasonable in whole or in part.

Note.—Frequently the most effective method of rebuttal is to establish a strong counter-argument. The negative by proposing a more reasonable way of achieving the same object may "counter" their opponents' arguments without answering them in detail. This forces on the affirmative the additional burden of proving that their alternative is the better of the two.

ILLUSTRATION OF A COUNTER-ARGUMENT

The counter-argument in this case would be the proposal to spend more on forest protection from fire, disease, etc., rather than embark on this somewhat doubtful proceeding.

(ii) *Summary.* Your summary should make clear to the audience those issues on which you have weakened or overthrown the affirmative case and should emphasize the fact that these issues are vital to the affirmative.

E.—*Leader of the Affirmative. Rebuttal Speech.*

As only a few minutes are allowed the speaker should not attempt to rebut many points. He should pick out the vital points, those at which the safety of his arguments has been most severely threatened. There is a temptation to answer trivial arguments, but it is waste of time to do so, since these will have already been discarded by the judge.

SUBJECTS FOR DEBATE

Resolved that:—

1. In the present stage of aviation, non-stop oceanic flights should be prohibited.
2. New Ontario offers better prospects for the young farmer than do the Prairie Provinces.
3. A special tax should be placed on all moving picture films not produced within the British Empire.
4. The influence of moving pictures has been beneficial.
5. French should be taught in all the public schools of Canada.
6. Animals have reasoning powers.
7. Professionalism in sports is beneficial.
8. The Canadian form of government is preferable to that of the United States.
9. Country life affords better opportunity for the development of character than life in a city.
10. The Canadian senate should be abolished.
11. Canada's immigration policy should be framed to attract the pioneer type of settler, irrespective of nationality.
12. All public schools in this inspectorate should be placed under a single board of trustees.

13. Military training should be made compulsory for all boys in public and high schools.
14. Orientals should be excluded from Canada.
15. Organized labour is a greater danger to the state than organized capital.
16. Old age pensions should be established in Canada.
17. The crow should be exterminated.
18. The freedom allowed to modern young people is good for them.
19. The individual becomes happier as his life is made easier by science.
20. The Ontario government should double its present equipment and staff for fighting forest fires.
21. The government should in cases of need provide a minimum living allowance for the dependents of all offenders confined in penal institutions.

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BULLETIN 332] [OCTOBER, 1927

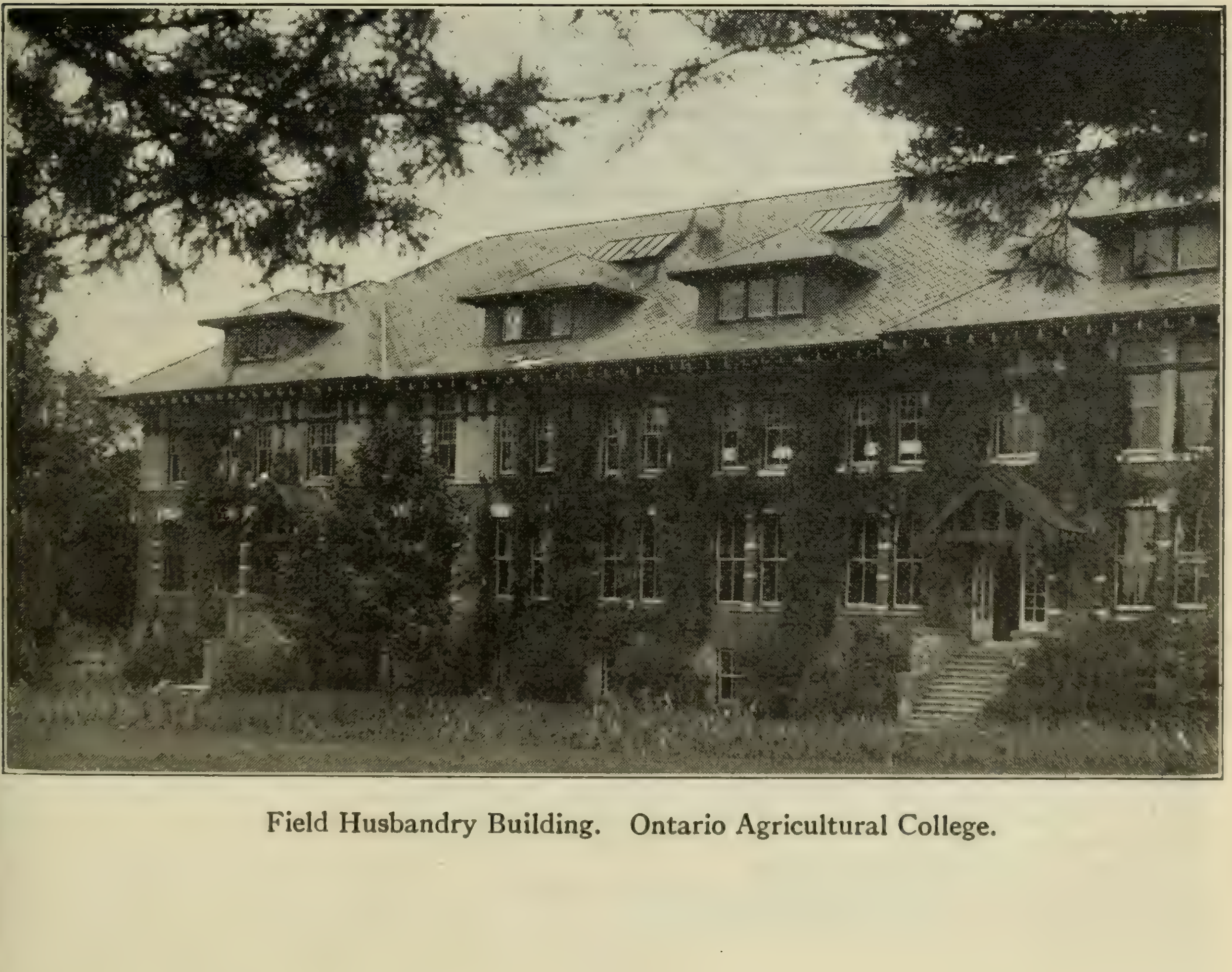
Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

FORTY YEARS' EXPERIMENTS WITH GRAIN CROPS

By C. A. Zavitz, B.S.A., D.Sc.

Professor of Field Husbandry and Director of Plant-Breeding and of Field Experiments



Field Husbandry Building. Ontario Agricultural College.

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INTRODUCTION

The writer has had direct charge of the experiments in field husbandry at the Ontario Agricultural College for forty-two years. In addition he has had direct charge of the co-operative experiments in agriculture throughout Ontario since 1886, in which year he distributed seeds and fertilizers to each of a dozen farmers who promised to conduct certain tests on their own farms. The plant breeding work with farm crops was started about twenty-seven years ago. Each of these three branches of research work developed in the one department has strengthened the other two.

The Department of Field Husbandry has unified the work of college teaching, scientific research and extension activities. This has promoted a high degree of economy, harmony and efficiency. The college teaching includes the short course work as well as that for the college diploma and for the university degree. The research work, as here applied, includes many laboratory experiments and investigations in addition to a large amount of plant breeding and of many practical and scientific experiments in the field. The extension activities, besides the co-operative experiments conducted through the medium of the agricultural and experimental union, includes interviews with farmers, public lectures, field inspections and practical demonstrations throughout the country, as well as the writing of articles for magazines, agricultural journals and newspapers in addition to the preparation of experimental results for official reports, bulletins and circulars and the conducting of a heavy correspondence with farmers, farmers' clubs and various agricultural organizations in Canada, and with many individuals and agricultural agencies in foreign countries.

ACKNOWLEDGMENTS

The entire work of the Field Husbandry Department is carried on through the co-operative effort and sympathetic interest of all those who are engaged in the work whether of experimentation, college teaching or extension teaching. In experimentation it extends from administrative policies throughout the entire system to the recording, studying, summarizing and typewriting the results. Very special mention, however, in connection with the experiments recorded in this bulletin is due to W. J. Squirrell, B.S.A., Associate Professor; A. W. Mason, B.S.A., Assistant Experimentalist; and A. E. Whiteside, Assistant in Plant Selection and Foreman. The first named has been on the Department continuously since 1900, the second since 1907, and the third since 1890. Mr. J. Buchanan, B.S.A., who is now the extension man of the Department has been on since 1894 with the exception of about twelve years nearly all of which time was spent as an official of the Agricultural College of Iowa. Cecil R. Klinck, B.S.A., who did excellent work as Assistant Plant Breeder in the Department for fifteen years died at Guelph, February 26th, 1922. To each of these men great credit is due in assisting to bring about the results which are recorded in this bulletin.

FIELD CROPS IN CANADA AND IN ONTARIO

Canada is an agricultural country and Ontario an agricultural province. The total annual agricultural revenue of Canada now reaches over one and two-third billions of dollars. The following table gives information gleaned from the Dominion Monthly Bulletin of Agricultural Statistics, prepared at Ottawa for the month of March, 1927. It gives the estimated gross annual agricultural revenue of Canada as a whole and also for the province of Ontario.

ESTIMATED GROSS ANNUAL AGRICULTURAL REVENUE

Items	Average 6 years (1921-1926)	
	Canada	Ontario
	$	$
Field crops	1,010,577,000	242,540,000
Dairy products	228,724,000	92,331,000
Farm animals	110,396,000	43,587,000
Poultry and eggs	63,034,000	26,701,000
Fruit and vegetables	52,494,000	17,987,000
Other items	24,281,000	11,368,000

The products included under "other items" are wool, fur-farming, maple products, tobacco, flax fibre, clover and grass seed and honey.

This furnishes in a very concise way the relative position of the annual agricultural revenue from field crops in comparison with those from other branches of agriculture for both Ontario and the Dominion. The annual returns from the field crops as given in the report of the Dominion Government are millions of dollars greater than those from all other agricultural items combined.

According to the statistics branch of the Ontario Department of Agriculture, in 1926 the total area in field crops in this province was 13,511,825 acres, including pasture on cleared land. The following table gives the number of acres of each of the eleven varieties of grain crops in Ontario in 1926, and also the average market value of each crop per acre per annum for the six years from 1920 to 1925 inclusive:—

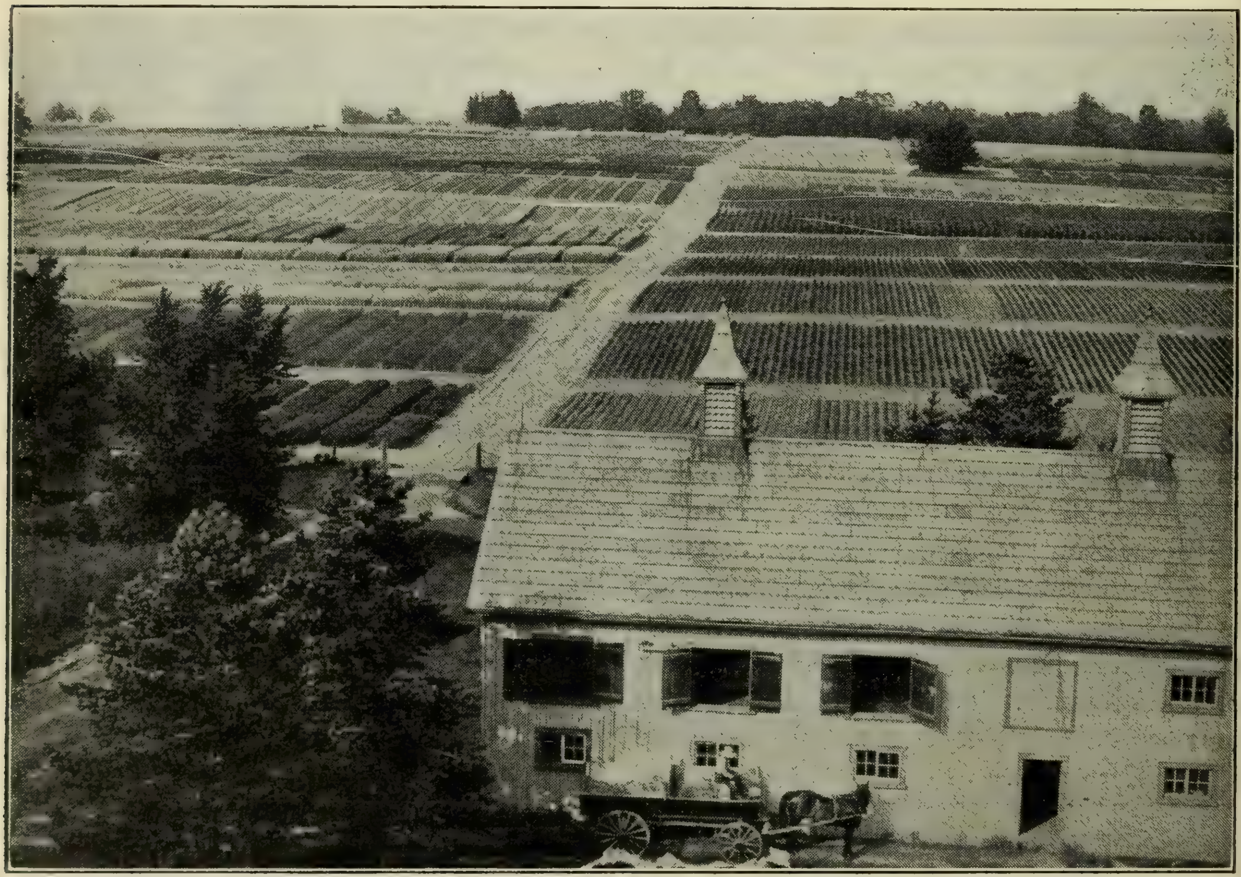
Crops	Average Market Value per Acre, 6 years, 1920-25	Number of Acres, 1926
Oats	$18 43	2,831,755
Fall wheat	32 79	807,015
Mixed grains	24 75	770,981
Barley	22 62	449.095
Buckwheat	18 53	234,870
Corn for husking	39 15	179,325
Spring wheat	22 32	115,497
Field peas	27 90	97,865
Rye	16 19	86,355
Field beans	40 08	51,721
Flaxseed	22 88	7,712

In 1926, 5,632,191 acres were used for the growing of the eleven classes of grain crops here referred to.

This bulletin deals with the experiments conducted with each of these crops and also with a number of the newer grain crops which have been more recently introduced. These include soy beans, sorghum, millet, sunflowers, vetches, lupines, lentils, Egyptian peas, grass peas, velvet beans, horse beans, etc.

EXPERIMENTAL GROUNDS AND METHODS OF OPERATION

The experimental grounds at the Ontario Agricultural College are under the direction of the Field Husbandry Department and consist of about eighty acres of land divided into approximately 3,000 plots on which experiments are being conducted with varieties of grain, fodder, silage, root, tuber, grass, clover and other crops; with commercial, green and barnyard manures; with selection of seed, dates of seeding, methods of cultivation, mixtures of grain, pasture grasses, etc. In addition the department directs the co-operative experimental work conducted on thousands of farms throughout the province through the medium of the Experimental Union.



A Partial View of the Experimental Field. Threshing Barn in Foreground.

The greater portion of the experimental grounds has a gentle slope towards the south-west and a smaller area has a slope towards the south-east. The soil is what might be termed an average clay loam. The lower portions of the land contain slightly more vegetable matter than the higher sections. The greater portion of the land has a four-year rotation, the rotation being: first, grain crops; second, cultivated crops; third, grain crops; and fourth, pasture. This is a special rotation particularly well suited to the experimental work as carried on at the college. About one-quarter of the land is manured each year with twenty tons of farmyard manure per acre. The twenty tons would be equal to about twelve good-sized loads of rotted manure. It will, therefore, be seen that the land receives an application of farmyard manure once every four years. The manure is applied to the cultivated crops. No commercial fertilizers are used except in distinct fertilizer experiments and these occupy a comparatively small area each year. Within the past twenty-four years two green crops have been ploughed under on each section of the grounds. In the two instances the green crop was used instead of the pasture crop.

The plots vary in size according to the requirements of the different experiments and the yields per acre are determined from the actual yields of the plots in every instance. All of these experiments are conducted with the greatest care and for several years in succession in order to secure strictly accurate results. These experiments deal with the crops grown on fully nine-tenths of the cultivated lands of Ontario. An immense amount of thought and care is required in planning, supervising and examining these plots, and in studying, comparing and summarizing the results for presentation in reports, bulletins, newspaper articles and lectures.

There are but few lines of work in which it is so absolutely necessary to use so much care in all details. Sometimes one standard variety and in some instances two standard varieties are repeated frequently throughout the tests as check plots. In numerous instances plot tests are repeated for at least six times in the one season. In addition, experiments are frequently conducted in what is known as the rod row method. We have used this method considerably in connection with our plant-breeding experiments for the last twenty-five years.

It is exceedingly important to repeat the experiments for several years in order to get results which are as reliable as possible. All of our field experiments are conducted for at least five years before they are dropped and many of them are continued for a much longer period of time. For instance, some of our variety tests have been repeated continuously for the past forty years.

For the results of some of the tests which we carried on for five or more years previous to 1926, the reader is referred to former reports and bulletins. The results of some of the experiments which have as yet been conducted for less than five years are held over until the test can be conducted through a longer period of time. As different seasons vary so much in temperature, rainfall, etc., the average results of experiments conducted for several years are of much greater value than those secured for a shorter length of time. Owing to the great care exercised in the work and the number of years through which the experiments are continued we are able to present the results with much confidence in their reliability and in their practical value.

FARMERS' CO-OPERATIVE EXPERIMENTS WITH FIELD CROPS

In the spring of 1886 the writer distributed seed and fertilizers to twelve farmers throughout Ontario, who agreed to conduct the tests on their own farms in accordance with instructions furnished by the college through the medium of the Experimental Union. That was the beginning of the present system of co-operative experiments which has been conducted throughout Ontario continuously for forty-one years. There are now forty-six distinct and separate co-operative experiments conducted over Ontario each year. In the forty-one-year period no less than 107,633 of these co-operative experiments have been conducted on individual farms. This means an average of 2,691 co-operative experiments conducted annually. During the latter part of the war, and immediately afterwards, the work dropped considerably. It has, however, steadily increased from 1,616 co-operative experiments in 1921 to 3,277 in 1926.

This shows that even in the past year the average number of co-operative experimenters was surpassed by no less than 586. These co-operative experiments which are conducted from the college through the medium of the Ontario Agricultural and Experimental Union are still occupying an important place in progressive crop production of the province.

It is impossible to estimate the great good which has been brought about in various ways through the medium of the co-operative experimental work. The principal conclusions from the carefully-conducted experiments carried on throughout the province are presented and discussed each year at the annual meeting of the Experimental Union. Any interested farmers of Ontario are always welcome to this gathering. The results of the co-operative experiments and the proceedings of the annual meeting are printed in the annual report which usually fills about sixty pages, and generally about 30,000 copies are issued. These annual reports may be obtained by writing to the Department of Agriculture, Parliament Buildings, Toronto.

HYBRIDIZATION AND PLANT BREEDING

The abundant economic production of food is probably the most fundamental material problem of the world. The crop production of a country can be increased by extending the acreage under cultivation and by obtaining higher yields per acre.

One of the aims of the Field Husbandry Department of the Ontario Agricultural College has been to bring about increased acre yields of high quality on the individual farms. With this object in view over 2,600 varieties of farm crops obtained from different parts of the world have been grown under test and their adaptabilities for Ontario conditions carefully studied. From some of the varieties of greatest merit improved strains and varieties have been obtained through careful selections from large nurseries, planted by hand, with thousands of selected seeds. As a last resort, controlled cross-fertilization has been used to originate new varieties superior to those obtained through selection from the varieties of highest record. For some time past we have grown and examined annually an average of about 50,000 hybrid plants of farm crops. The plant improvement work has included grain, forage, root and tuber crops.

The varieties of highest merit obtainable by plant breeding at the College are distributed to the farmers for co-operative experiments on their own farms. If they prove worthy under the local conditions they are soon increased by the experimenters themselves at no additional cost for seed. The surplus is often sold to neighbours and to others to mutual advantage. Through this process the acre yields of several of the farm crops of Ontario have been increased considerably.

Statistics of farm crops have been collected by the Ontario Department of Agriculture continuously since 1882. From this accumulated data we learn that the increases in the acre yields of oats, barley and winter wheat for the last two dozen years, in comparison with the former years, amounted to 318,668,775 bushels which, valued at average market prices, would reach a total of $207,355,585. This increased value already obtained at very slight cost would not only pay the entire net expenditure of the Ontario Agricultural College for the past half century but it would, in addition, maintain the College at its present cost for the next 480 years.

The increases in acre yields of these three, as well as of some other farm crops, are constantly becoming greater as the leading new varieties become better established and as others are introduced from time to time.

The large increases in yields per acre of these major grain crops are even more interesting when we realize that actual decreases in acre yields for the same period have taken place throughout Ontario with some of the minor farm crops which have not been so influenced by new varieties originated at our College. It should be remembered that there is a natural tendency towards gradual decreasing yields of all kinds of farm crops in a comparatively new country.

Undoubtedly the general use of the high-yielding new varieties of good quality distributed from the College and used in the co-operative tests of the Ontario Agricultural and Experimental Union has been the great factor in bringing about this general increase in acre yields of the principal grain crops of Ontario.

The great influence from hybridization and plant breeding as it affects grain crops is impossible of full estimation. It takes many years to accomplish results which are really worth while. Some of the earlier work of this Department is now recognized as having a direct bearing on the improvement of the quantity and the quality of crops throughout the country. The work carried on more recently will exert its influence in future years. When the writer was absent last summer for some weeks on sick leave he received a letter from R. Keegan, B.S.A., who has been Assistant in Plant Breeding since 1923, from which the following is quoted:—"I might say that present appearances indicate that our best chances of success in obtaining high-yielding new varieties are to be found in varieties developed here. We have, as you know, many importations but a very small number of these can compare in appearance and vigour, at the present time, with strains developed here." We have learned through our experimental work of past years that in those classes of farm crops in which we have put the most work we have been able to originate varieties through hybridization and selection which are better suited to Ontario than the varieties imported from the various parts of the world.

Thirteen Leading Varieties of Farm Crops Originated in the Field Husbandry Department of the Ontario Agricultural College.

WEATHER CONDITIONS

As it is important for a proper understanding of the results of experiments with farm crops to have a knowledge of the weather conditions in the locality in which the experiments have been conducted, the amounts of rainfall and the mean temperature in the six months of the growing season in each of the past twenty-seven years are here presented. These have been carefully determined in each of these years by the Department of Physics at the College, from which department we have received the information.

Inches of Precipitation during the Six Growing Months

Year	April	May	June	July	August	September	Total
	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1900	1.69	1.03	4.47	3.05	.87	1.52	12.63
1901	2.24	3.26	1.53	4.07	3.51	2.45	17.06
1902	2.43	1.67	3.06	6.43	2.18	3.58	19.35
1903	2.69	2.44	3.05	2.67	3.47	1.48	15.80
1904	2.10	3.01	2.86	4.99	3.88	2.80	19.64
1905	1.82	3.89	3.24	4.60	1.98	2.85	18.38
1906	1.44	2.71	4.06	4.65	2.13	2.49	17.48
1907	1.66	2.64	1.11	1.92	.62	2.87	10.82
1908	1.33	3.47	3.21	3.25	2.75	.73	14.74
1909	3.60	3.43	1.33	4.54	.89	.86	14.65
1910	3.13	2.75	.78	2.09	3.18	3.00	15.02
1911	1.67	1.64	.89	1.95	2.53	3.42	12.10
1912	1.14	5.64	1.51	2.53	6.07	3.08	19.97
1913	3.53	1.37	2.03	3.26	2.88	1.49	14.56
1914	2.86	2.04	2.76	1.23	4.21	1.96	15.06
1915	2.23	2.24	2.27	5.87	6.16	3.92	22.69
1916	3.53	4.41	4.46	1.21	1.68	1.83	17.12
1917	3.36	3.29	6.40	7.54	3.28	1.41	25.28
1918	2.38	4.22	4.56	1.47	5.18	4.06	21.87
1919	2.58	5.76	1.43	.74	3.69	2.98	17.18
1920	3.59	.65	3.19	4.73	2.13	2.19	16.48
1921	4.48	3.03	1.80	6.04	1.68	3.80	20.83
1922	4.76	2.95	4.66	2.52	2.22	3.15	20.26
1923	2.86	4.00	4.46	3.11	4.86	3.34	22.63
1924	2.38	5.86	2.49	4.58	2.58	4.61	22.50
1925	1.53	1.75	2.45	4.01	3.39	3.94	17.07
1926	2.37	1.70	3.97	1.65	8.59	5.31	23.59
Average 27 years	2.57	2.99	2.89	3.51	3.21	2.78	17.95

A record of the rainfall for the past twenty-seven years forms interesting material for study. It will be seen that there was a variation in total rainfall for the six months from 10.8 in 1907 to 25.3 in 1917. In 1926 the amount of rain which fell in the six months was the second highest of the whole period. It is interesting to note that in 1926 the amount of rain which fell was greater in August and also in September than the amounts recorded for the same months in any of the other years throughout the period. The rainfall, however, in each of the months, April, May and July for the same year was below the average.

The tabulated data in regard to rainfall and temperatures can readily be referred to when wishing to study the weather conditions at the special time when an experiment was conducted, the results of which are presented in this bulletin.

MEAN TEMPERATURES IN EACH OF THE SIX GROWING MONTHS

Year	April	May	June	July	August	September	Average
1900	44.2	55.2	64.6	68.4	71.7	64.5	61.4
1901	45.8	53.8	64.3	73.0	65.4	60.7	60.5
1902	39.7	52.8	57.8	68.7	63.2	59.3	56.9
1903	42.2	56.6	60.1	69.5	62.5	63.1	59.0
1904	34.0	53.3	62.5	65.7	64.0	58.2	56.3
1905	41.2	52.8	62.6	67.7	63.9	61.6	58.3
1906	44.2	55.2	65.2	67.7	69.5	63.6	60.9
1907	38.7	48.6	61.4	66.4	68.7	62.7	57.8
1908	38.8	55.9	65.4	69.5	65.2	64.5	59.9
1909	39.3	50.6	64.9	68.2	67.7	57.9	58.1
1910	45.9	51.5	63.3	69.5	66.3	56.1	58.8
1911	40.3	61.7	65.4	71.0	71.6	59.7	61.6
1912	41.3	51.7	62.4	67.1	61.5	61.8	57.6
1913	43.9	52.5	63.4	67.6	67.0	57.4	58.6
1914	39.7	56.6	62.0	68.6	66.3	58.3	58.6
1915	48.4	49.6	60.1	65.8	63.6	61.9	58.2
1916	42.6	52.8	56.2	73.8	69.0	58.0	58.7
1917	40.1	47.4	59.9	69.0	64.9	55.2	56.1
1918	42.9	58.2	60.6	67.5	69.5	53.0	58.6
1919	44.2	53.4	70.2	70.5	65.8	61.1	60.9
1920	37.9	52.8	62.7	62.4	67.3	61.0	57.4
1921	48.7	56.4	65.6	74.1	65.3	63.6	62.3
1922	42.9	58.8	63.9	66.0	65.6	61.4	59.8
1923	41.1	51.5	65.3	66.3	64.3	59.8	58.1
1924	40.9	46.7	61.8	64.2	64.6	54.5	55.5
1925	44.7	48.5	64.5	64.8	65.6	60.98	58.2
1926	34.9	51.3	59.1	66.1	66.6	57.4	55.9
Average 27 years	41.8	53.2	62.8	68.1	66.2	59.9	58.7

CROP ROTATIONS

In our experimental grounds it is necessary to grow a comparatively large amount of grain in order to meet the requirements of the various tests. The main rotation used, therefore, on the land devoted to the testing of varieties, dates of seeding, methods of cultivation, etc., extends over four years and is as follows: First year, cultivated crops; second year, grain crops; third year, pasture; and fourth year, grain crops. In another section of twenty-five acres in the experimental grounds a three-year rotation is conducted as follows: First year, cultivated crops; second year, grain crops; and third year, leguminous crops. The cropping of the College farm is arranged mainly into a four-year rotation as follows: First year, cultivated crops; second year, grain crops; and third and fourth years, hay and pasture.

It is important that each farmer adopt on his own farm the rotation of crops which is likely to give the best results to meet the conditions of the farm and the requirements of his own particular system of farming. While it is true that no rotation is the best under all conditions it is equally true that certain underlying principles should be applied as much as possible in each rotation. The rotation should be so arranged that the crop of each year should not only be the suitable crop for that season but would also, in some way or other, form a suitable preparation for the crop of the following year. A crop such as corn, potatoes or roots when carefully cultivated assists the following crop by the destruction of weeds and of weed seeds and by liberating plant food. The grain crops should be sown in such a way that they not only furnish good results themselves but make good nurse crops for seeding with grasses, clovers or alfalfa. The leguminous crops such as the clovers and alfalfa not only furnish a large amount of nutritious feed but also improve the mechanical conditions of the soil and add to the land some of the free nitrogen taken from the atmosphere and stored throughout the plant part of which is left in the root residue thus improving the land for the crops following. Any person who has not given the subject of crop rotation his careful thought and attention has not lived up to his opportunities in making use of one of the best features in high crop production from an economical standpoint.

STANDARD WEIGHTS PER BUSHEL

In order to present as complete information as possible regarding the standard widghts of farm products, application was made to the Seed Branch at Ottawa and the following information compiled by Mr. C. Sweet, Acting Commissioner, Seed Branch, Ottawa, was received on June 3rd, 1927. The legal weights of the crops for Canada here given are those used throughout this bulletin and the information should be of considerable service to the farmers of Ontario in having definite information as to the legal weights of the different products. For some crops, however, such as emmer and sunflower, the weight is established by custom rather than by any legal sanction.

Kind of Seed	Legal Weight, Canada lbs.	Legal Weight, United States lbs.	Range applicable in different States lbs.
Oats	34	32	26–32
Wheat	60	60	.....
Barley	48	48	27-52
Rye	56	56	50–56
Flax	56	56	50–56
Corn	56	56	54–56
Buckwheat	48	42	40–56
Peas	60	60	.....
Beans	60	..	55–62
Castor Beans	40	50	46–50
Soy Beans	60	..	.....
Vetches	60	..	.....
Hemp	44	44	44–50
Alfalfa	60	60	60–64
Red Clover	60	60	60–64
Alsike	60	60	60–64
Sweet Clover	60	60	60–64
White Clover	60	60	60–64
Crimson Clover	60	60	60–64
Millet Foxtail	48	..	.....
Timothy	48	..	42–60
Canadian Blue Grass	14	..	.....
Kentucky Blue Grass	14	14	.....

COMPARATIVE RESULTS FROM DIFFERENT CLASSES OF FARM CROPS

In each of the past twenty-six years two leading varieties of oats, barley, spring wheat, field peas, spring rye, hulless barley and emmer have been grown in our experimental grounds under uniform conditions of soil and climate. The object of this experiment has been not so much to compare one variety with another, as to secure definite information regarding the relative productiveness of different classes of farm crops. It is strange but nevertheless true that but little definite work has been done at Agricultural Experiment Stations in comparing in this positive and comprehensive way the relative productiveness of our most common grains. As the experiment was conducted in duplicate each year it will be seen that we now have the results of fifty-two separate and distinct tests conducted in the twenty-six year period with these seven classes of farm crops. In some years the experiment was conducted on high land, in other years on low land, and in others upon land which had a gentle slope; in some seasons facing the north-east and in others the south-west. On no occasion was this experiment conducted on particularly heavy or especially light soil, but on loam which varied somewhat from year to year, from fairly light to medium heavy. The results of this experiment are very interesting.

In order to add to the value of the results of this experiment, we have used the tabulated results of the digestible constituents of the different classes of crops as presented in the eighteenth edition of the book entitled "Feeds and Feeding," written by Henry and Morrison, and printed in 1923. By multiplying the yields per acre by the percentage of digestible constituents given for each crop, the amounts of digestible constituents per acre have been worked out. It should be understood that the digestible fat is usually estimated as being 2.25 times as valuable as an equal amount of digestible carbo-hydrates. The following table gives the average annual results of the fifty-two distinct experiments conducted within the past twenty-six years:—

Class of Crop	Straw (tons)	Grain (lbs.)	Pounds of Digestible Constituents in Grain			
			Crude Protein	Carbo-hydrates	Fat	Total
Barley	1.66	2,603	234.3	1738.8	41.6	2066.8
Emmer	1.87	2,420	229.9	1529.4	41.1	1851.3
*Hulless Barley	1.58	2,237	187.9	1510.0	44.7	1798.5
Oats	2.18	2,525	244.9	1315.5	96.0	1777.6
Wild Goose spring wheat	2.01	1,765	194.2	1133.1	28.2	1390.8
Rye	2.03	1,683	166.6	1151.2	20.2	1363.2
Field peas	1.39	1,737	330.0	969.2	10.4	1323.6

***Digestion co-efficients not being available those for a similar feed have been used.**

Barley not only heads the list in average yield of grain per acre but also in pounds of digestible constituents as will be seen in the tabulated results for the twenty-six year period. Although the oat crop is the most abundantly grown in the province and gives the greatest yield of straw per acre it stands second in the list in digestible crude protein, fourth in carbohydrates and highest in fat per acre. In total digestible constituents it is fourth in the list, being surpassed by barley, emmer and hulless barley. Field peas, although considerably the highest in crude protein, stand at the bottom in total number of pounds of digestible constituents per acre.

The Statistics Branch of the Ontario Department of Agriculture located in the Parliament Buildings at Toronto, has gleaned statistics throughout the Province regarding crop production in each of the past forty-five years, starting in 1882. The results are given annually in bulletins and reports and furnish some interesting material for study. Grains are reported in bushels per acre. By multiplying the average number of bushels per acre by the standard weight per measured bushel of each class of grain, a more definite comparison can be made. Again, by multiplying the pounds of grain per acre by the percentage of digestible constituents of each, the amount of digestible material per acre of each class presents even a more accurate determination of the real value of the feed produced per acre from the different classes of grain crops grown in Ontario. As a basis of study the results for the estimated crops of Ontario have been worked out in a similar way to those presented in the foregoing table in connection with a distinct experiment conducted at the College. The following table gives the estimated annual yields of grain per acre over a period of forty-five years, and in the case of each of eight classes of crops and the amount of digestible constituents in each instance:—

Class of Crop	Grain (lbs.)	Pounds of Digestible Constituents in Grain			
		Crude Protein	Carbohydrates	Fat	Total
Barley	1,373	123.6	917.2	22.0	1090.2
Fall Wheat	1,320	114.8	895.0	18.5	1052.0
Field Peas	1,146	217.7	639.5	6.9	873.3
Oats	1,224	118.7	637.7	46.5	861.7
Wild Goose spring wheat	984	108.2	631.7	15.7	775.4
Spring Rye	924	91.5	632.0	11.1	748.4
Beans	972	182.7	498.6	7.8	698.9
Buckwheat	1,003	81.2	498.5	25.1	635.9

As in the results of experiments at Guelph it will be observed that throughout the Province barley occupies first and oats fourth place in production of digestible grain constituents per acre. This table varies somewhat from the former one owing to the fact that emmer and hulless barley are included in the College tests while fall wheat, beans and buckwheat were omitted in this regular test. In the two previous tables the crops occupy the same relative order in production of total digestible food material with the single exception that the estimated yield of field peas per acre throughout Ontario for the forty-five year period stands higher in the list than the yield of field peas in the experiments at the College extending over a period of twenty-six years.

CONTINUOUS GROWING OF VARIETIES WITHOUT CHANGE OF SEED

Each of ten varieties of farm crops has been grown in an experimental way at our College for the forty years from 1887 to 1926 inclusive. Each of thirty-one varieties have been grown from thirty to thirty-seven years without change of seed. The results of tests conducted throughout this period will be presented in the following pages. The detailed results are very interesting and show that varieties of grain crops may be grown in Ontario for a long period of time without change of seed and with very satisfactory results if care is exercised in using seed of good quality.

It is still considered necessary by a few farmers to change seed quite frequently from one soil to another. The question of frequent change of seed has been discussed and argued for many years. There are some strong advocates for a frequent change of seed while other men are just as strong in advocating the continuous growing of varieties on the same farm for a number of years and pecially if they have choice varieties and have been careful in the selection of seed from year to year. An increasing number of practical farmers are realizing more and more the fact that in very many cases they are able to grow the same varieties for a long time without change of seed providing proper care is taken in growing varieties suitable for the soil, in the careful selection of the seed and in the cultivation of the land. In the experiments which have been conducted at Guelph within the past forty years care has been taken to have the crops grown under as nearly normal conditions as possible. The soil on which these crops have grown has changed but little in fertility and no commercial fertilizers have been used on the land. The crops simply fitted into the four-year rotation which is considered by practical farmers to be a more severe rotation than the one used on the College farm as in our experimental grounds in the four-year rotation two crops of grain and one cultivated crop have been removed from the land, the crop in the other year being used for pasture. No plant selection was used in these tests but good seed was sown each year. It is sometimes wise for the practical grower to change his seed when better and more profitable varieties are obtainable. Otherwise, it is often to the interest of the careful grower to change seed as seldom as possible.

About forty years ago the Black Tartarian was reported as the best all-around oat for Ontario and was grown by many farmers. It is still imported and grown to a very limited degree. In the experiments at Guelph for the last nine years the O.A.C. No. 144 has surpassed the Black Tartarian variety by an average annual yield of 27.7 bushels per acre, the former giving 89.6 and the latter 61.9 bushels per acre. The evolution in oat varieties in Ontario makes an interesting story and the farmer who does not secure the best varieties, not only of oats but of all farm crops is not living up to his best opportunities

QUANTITIES OF SEED OATS PER ACRE

The question of the amount of seed of the cereal grains to be sown for the best results has been discussed many times and in many places. Experiments have also been conducted with the object of securing information on this problem in different countries, and yet we have reached no unanimity in regard to the matter. We find, for instance, in Canada that the amounts of oats which are sown per acre will vary from one to four bushels, and in Scotland the quantity frequently reaches six and sometimes seven bushels of seed per acre. We find a few very strong advocates of using as small a quantity as one bushel of oats per acre, while others will argue as earnestly for the advisability of using as high as six bushels or more per acre. The question then arises as to why there is such a difference in the views of the practical men who have had long experiences in the growing of grain upon their individual farms. I think we are safe in coming to the conclusion that these variations are caused partly on account of knowledge, and partly on account of ignorance. It is undoubtedly true that the amount of seed per acre which would give the highest results under certain circumstances would not give the highest results under other conditions. There are many factors which exert an influence in determining the quantity of seed to use to give the best returns, each of these factors producing its own particular influence. The fertility of the soil, the state of cultivation, the moisture content of the soil, the variety of the crop, the method of seeding, the date of seeding, and many other factors, apparently exert their respective influence in regard to the amount of seed to be sown in order to secure the highest returns. If this be true it can readily be seen that we cannot come to a definite conclusion regarding the quantity of seed to use per acre of any class of farm crop which would give the highest returns under all circumstances. Nevertheless, it must be admitted that definite knowledge regarding the influence of some of the factors above referred to, is very meagre, indeed. We believe as knowledge along these lines accumulates we shall be in a very much better position to know what is likely to give satisfactory results under the varying conditions in which a crop is to be grown. We believe, therefore, that any new and definite information obtainable which will throw additional light on this problem will be appreciated. In 1909 an experiment was started in planting oats at different distances apart. One or two other experiments ran concurrently and others followed later with the object in each case of gleaning further information regarding the influence of growing oat plants at different distances apart. Some exceedingly valuable information has resulted.

In the main experiment which was started in 1909 seed oats were planted by hand in squares, the kernels being placed one, two, three, four, six, eight and twelve inches apart each way. The experiment was conducted in duplicate with each of four varieties in each of six years. The test, therefore, has been repeated forty-eight times, involving in all three hundred and thirty-six plots. The varieties used were Joanette, a heavy stooler; Banner and Abundance, medium stoolers; and Tartar King, a light stooler. This experiment involved a large amount of labour and great care was exercised by trained men in looking after the various details of the test. The following table gives the average results of the forty-eight separate tests in the six-year period:—

Inches between plants	Seed Sown per Acre		Height (ins.)	Per cent. lodged	Days to mature	Per cent. rust	Heads per plant	Barren Spikelets per plant	Lbs. per measured Bushel	Yield per Acre	
	lbs.	bush.								Straw (tons)	Grain (bush. by wt.)
1 x 1	430.9	12.67	20	4	89	11	1	.9	32.9	1.74	36.27
2 x 2	106.9	3.14	28	11	93	13	1	1.9	35.1	1.59	45.07
3 x 3	47.6	1.40	33	21	95	16	2	3.7	33.9	1.52	51.56
4 x 4	26.8	.79	33	33	97	18	2	5.2	32.2	1.33	48.00
6 x 6	11.9	.35	35	38	99	21	5	10.8	30.1	1.39	44.37
8 x 8	6.7	.20	35	36	100	23	7	18.2	28.0	1.24	37.32
12 x 12	3.0	.09	35	31	102	28	11	36.0	25.4	1.07	25.46

The table here presented contains results, the significance of which can not be attained in a glance although some of the figures are exceedingly suggestive. It is interesting to note the regularity of increases and decreases from different plantings. The results are stabilized largely by the fact that the experiment was conducted in duplicate with each of four characteristic varieties in each of six years, thus covering quite a variety of conditions. The distance between plants had a marked influence on most of the questions studied as indicated in the headings of the table. Naturally in an experiment of this kind extremes were used as a basis of comparison. It will be seen that amount of seed oats used varied from three pounds to over twelve bushels per acre. These extremes go to make the results more interesting and valuable and give excellent foundation for further research work. The records should be of very great interest both to practical farmers and to investigators.

Greatest lodging took place when the grains were planted six inches apart each way and there was a variation in the per cent. of lodged grain from four for the thickest to thirty-one for the thinnest seeding.

The thickest seeding was the earliest to mature and as the amount of seed planted became less the number of days to maturity increased.

The rust also increased in amount as the rates of planting became less so that the thinnest seeding had more than twice the amount of rust as compared with the thickest.

The stooling of oats is regulated by many factors. Some varieties stool much more abundantly than others. The stooling of all varieties, however, can be very greatly regulated by the thickness of seeding. It will be seen from the results that the thickest seeding permitted only one head per plant while the thinnest seeding permitted the average plant of the average variety to have eleven heads.

It will also be seen that the amount of barren spikelets which are often noticed in a field of oats is influenced very largely by the rate of seeding.

The oats produced on plants grown two inches apart each way gave the highest average weight per measured bushel and those grown the farthest apart produced the lightest grain, a difference of almost ten pounds per measured bushel.

The greatest yield of straw per acre was produced from the heaviest and the lightest yield from the thinnest seeding.

The highest average yield of grain per acre was produced from the plants which were three inches apart each way. From this maximum yield there was a gradual decrease towards both the heavier and lighter seeding. It might be rather difficult for some practical growers to realize that three pounds of oats per acre when evenly distributed are likely to give a yield of about one-half as much as the oats which were sown at approximately a bushel and a half per acre.

Many other observations can be made by carefully studying these summary results.

DISTANCES BETWEEN OATS IN THE DRILL

Concurrently with the foregoing experiment another was started in 1909 in which oats were planted in rows which were eight inches apart. The seeds were planted a half, one, one-and-a-half, two, four, six, and eight inches apart in the rows. This experiment was also conducted in duplicate with each of the same four varieties. The results, therefore, as in the former case, represent forty-eight distinct and separate tests or in all three hundred and thirty-six plots. The following table gives the average record of this experiment for the six-year period:—

Distance between plants, inches	Seed sown per Acre		Height (ins.)	Per cent. lodged	Days to mature	Per cent. rust	Heads per plant	Barren spikelets per plant	Lbs. per measured bushel	Yield per Acre	
	lbs.	bush.								Straw (tons)	Grain (bush. by wt.)
½ x 8	136.5	4.01	27	35	90	19	1	1.0	34.84	1.55	44.74
1 x 8	68.3	2.01	32	41	91	23	1	2.0	33.23	1.55	44.95
1½ x 8	45.5	1.34	34	42	92	23	2	3.7	32.50	1.65	48.78
2 x 8	34.2	1.01	35	45	93	23	3	5.2	31.30	1.59	43.62
4 x 8	17.1	.50	36	45	95	26	5	10.9	30.04	1.64	42.20
6 x 8	11.4	.34	36	43	95	28	8	21.2	29.85	1.51	36.74
8 x 8	8.5	.25	35	35	96	32	14	40.3	28.84	1.47	33.15

The seeding of the oats in this experiment more approximately approaches the grain drill method used by practical farmers. As the extremes in the amount of seed used did not vary as greatly as in the former experiment the results naturally come within a narrower range. A study of the table in conjunction with the former one form some interesting comparisons. Detailed observation will be left largely for the reader to make for himself.

It will be observed that the oats put in rows eight inches apart with the plants one and one-half inches apart in the row gave the highest yield of both grain and straw per acre.

Closer Distances Between Oats in the Drill

Based on the results of the foregoing experiment another test was started in 1916 and between that date and 1923 was repeated successfully in five different years. The same four varieties of oats were used and the experiment was conducted in duplicate in each of the five years. The seed was planted in drills which were eight inches apart and the distances in inches allowed between the plants in the drill were as follows: one and one-eighth, one and two-eighths, one and three-eighths, one and four-eighths, one and five-eighths, one and six-eights, and one and seven-eighths. It will be seen that all distances between the seeds were less than those of the second and fourth plots in the previous experiment. The following table gives the results in grain production of the five years' test:—

Distance between plants, inches	Average 6 years		Average 5 years		
	Seed used per acre (lbs.)	Width of 25 Straws. (inches)	Weight per measured bushel (lbs.)	Yield per Acre	
				Straw (tons)	Grain (bushels by weight)
$1\frac{1}{8}$ x 8	69.41	3.59	35.48	1.84	64.58
$1\frac{2}{8}$ x 8	62.75	3.62	35.51	1.97	68.48
$1\frac{3}{8}$ x 8	56.84	3.69	35.62	2.15	72.26
$1\frac{4}{8}$ x 8	52.29	3.76	34.59	2.09	68.75
$1\frac{5}{8}$ x 8	48.13	3.77	34.54	2.25	72.67
$1\frac{6}{8}$ x 8	44.82	3.83	34.66	1.99	66.52
$1\frac{7}{8}$ x 8	41.72	3.80	34.89	1.78	61.42

It will be seen that the highest yields were produced in the eight-inch drills when the plants were from one and three-eighths to one and five-eighths inches apart. The amount of seed used ranged from about forty-eight to fifty-seven pounds per acre. It, of course, must be understood that the seed was good, evenly distributed on land which was well cultivated.

Distance Between Drills of Oats

Ending in 1923 an experiment was conducted for six years in which four varieties of oats were tested in duplicate with the object of comparing the results from rows six and seven inches apart. In all instances the oat grains were planted one and one-half inches apart in the row. The yields per acre from the two methods were very close but as the details show some slight irregularities the results are withheld for further investigation.

OATS BROADCASTED AT THREE RATES PER ACRE

For eight years, from 1919 to 1926 inclusive, an experiment has been conducted in which each of five varieties of oats has been sown broadcast at the rates of two and one-half, two, and one and one-half bushels per acre. In some seasons the experiment was conducted on both high and low land. The average results for the entire experiment for the eight-year period are here presented in tabulated form:—

Seed per acre (bushels)	Height of crop (ins.)	Per Cent. Rust	Per Cent. Lodged	Per Cent. of Hull	Pounds per Measured Bushel	Yield per Acre
						Grain (Bush. by weight)
2½	43.2	8.1	25.6	27.9	32.77	72.9
2	43.0	9.5	27.2	28.8	32.51	76.1
1½	43.1	9.5	29.8	28.2	32.38	75.4

As in the previous experiment the percentage of lodging increased as the amount of seed per acre decreased. Of the individual varieties three gave the highest returns from two bushels and two from one and one-half bushels per acre. Four out of the five varieties gave the lowest returns when two and one-half bushels were used per acre. The average results show the highest yield from two bushels and the lowest from two and one-half bushels.

BANNER OATS AT THREE RATES OF SEEDING

In each of five years finishing with 1924, Banner oats were sown in the experimental plots at the rates of two and one-half, two, and one and one-half bushels of seed per acre. The experiment was repeated twelve times each year for each rate of seeding, making in all one hundred and eighty plots. The average results for the five-year period are here presented:—

Seed per acre (bushels)	Lbs. per Measured bushel	Yield per Acre	
		Straw (tons).	Grain (bush. by weight)
2½	31.3	1.91	66.79
2	32.1	1.96	70.93
1½	31.5	1.93	69.26

As in the case of the foregoing experiment the highest yield per acre was obtained from sowing two bushels, the medium from one and one-half and the lowest from two and one-half bushels per acre.

BARLEY AT THREE RATES OF SEEDING

Five leading varieties of barley have each been sown at the rates of two and one-half, two, and one and one-half bushels per acre in the years 1923-24-25-26. The following table gives the average results for all of the varieties for the four-year period:—

Seed per Acre (bushels)	Height of Crop (inches)	Per cent. lodged	Days to mature	Pounds per measured bushel	Yield per Acre	
					Straw (tons)	Grain (bushels by weight)
2½	27.38	23.28	104.2	51.19	1.46	48.49
2	27.76	22.02	104.5	51.09	1.58	50.34
1½	27.98	20.30	104.6	50.96	1.54	47.85

In three out of the four years two bushels per acre gave the highest return, but in 1925 one and one-half bushels of seed per acre gave the highest yield.

SPRING WHEAT AT THREE RATES OF SEEDING

In 1925 and in 1926 an experiment was conducted in sowing each of three leading varieties of spring wheat at the rates of six, five, and four pecks per acre. This experiment will be continued for several years. The average results of the two years show that the highest weight of grain per measured bushel was from the five pecks and the slightly highest yield of grain per acre from the four pecks. The results vary somewhat in the two years so that the future returns might make changes in the records.

WINTER WHEAT AT THREE RATES OF SEEDING

An experiment was started in 1920 and has been continued to the present time, in which two varieties of winter wheat have been sown at the rates of five, six, and seven pecks of seed per acre. The following table gives the average results of the two varieties for the seven-year period:—

Seed per Acre (pecks)	Height of Crop (inches)	Per cent. rust	Per cent. lodged	Weight of Grain per measured bushel (pounds)	Yield per Acre	
					Straw (tons)	Grain (bushels by weight)
7	42.8	4.1	12.0	61.31	2.53	51.16
6	42.3	4.2	9.9	61.15	2.47	50.19
5	41.8	2.7	6.4	61.50	2.32	47.72

The results from sowing winter wheat at different quantities per acre favour fairly thick seeding.

For six years in succession another experiment was conducted with each of two varieties of winter wheat by sowing each broadcast and with a grain drill. This experiment, therefore, required seventy-two plots. The following table gives the average results for the six-year period.

In four out of the six years the seeding of two bushels per acre gave the highest yield.

It would probably be an advantage if some farmers would sow winter wheat a little thicker and oats a little more thinly than is their general practice if the highest returns are to be obtained.

Seed per Acre (bushels)	Pounds per measured bushel	Yield per Acre	
		Straw (tons)	Grain (bushels by weight)
2	59.34	3.02	43.87
1½	59.26	2.96	43.30
1	59.15	2.68	40.15

SPRING RYE SOWN AT DIFFERENT RATES PER ACRE

In each of the five years from 1918 to 1923 inclusive, an experiment was conducted in sowing spring rye at five different quantities of seed per acre. The O.A.C. No. 61 variety was used throughout and the experiment was conducted in duplicate each year. The experiment, therefore, required fifty plots in the five years. The following table gives the results of the experiment for the five-year period:—

Seed per Acre (pounds)	Days in reaching maturity	Height of Crop (inches)	Pounds per measured bushel	Yield per Acre	
				Straw (tons)	Grain (bushels by weight)
168	96.2	48	53.9	2.09	30.78
140	96.4	49	53.9	2.06	30.88
112	96.8	50	53.9	1.97	30.63
84	97.4	50	53.6	1.91	29.76
56	98.0	50	53.3	1.86	28.53

As the standard weight per measured bushel of rye is fifty-six pounds, it will be seen that the highest yield was produced from sowing two and one-half bushels of seed per acre. The results, however, show that spring rye is a very adaptable crop and when sown from one to three bushels per acre the resulting yields are not so very different. If the amount of seed used is subtracted from the crop produced even one bushel of seed per acre gave a very good return in yield of grain.

WINTER RYE AT THREE RATES OF SEEDING

For five years in succession, from 1922 to 1926 inclusive, an experiment was conducted in sowing winter rye at the rates of two and one-half, two, and one and one-half bushels per acre. The Rosen variety was used throughout and the experiment was conducted in duplicate. The following gives the average results for the five-year period:—

Seed per Acre (pounds)	Pounds per measured bushel	Yield per Acre	
		Straw (tons)	Grain (bushels by weight)
140	56.03	3.76	68.42
112	56.07	3.73	68.90
84	56.23	3.64	68.36

In each of the past three years this experiment has included six instead of three rates of seeding as follows: four, five, six, seven, eight, and ten pecks per acre. The average results for the three years show the highest returns from the two heaviest rates of seeding.

FIELD PEAS AT THREE RATES OF SEEDING

In each of the past three years, 1924-25-26, each of two varieties of field peas were sown in the experimental grounds at the rates of three, two and one-half, and two bushels of seed per acre. The experiment is not yet completed but even the three years' results are interesting and are valuable as far as they go. As peas vary so much in size the average results of different varieties are not as valuable as those of the separate kinds. The Canadian Beauty is a large white pea and it has been grown extensively in Ontario for a good many years. The O.A.C. No. 181 is a comparatively new pea originated at the College through hybridization. The peas are white and considerably smaller than those of the Canadian Beauty variety. The following table gives the results of each variety for each of the three years:—

Seed per Acre (bush.)	1924		1925		1926		Ave. 3 years	
	Canadian Beauty	O.A.C. No. 181	Canadian Beauty	O.A.C. No. 181	Canadian Beauty	O.A.C. No. 181	Canadian Beauty	O.A.C. No. 181
3	21.40	32.47	23.82	39.67	40.37	51.12	28.53	41.09
2½	20.40	31.25	25.42	40.48	39.63	52.35	28.48	41.36
2	22.23	30.78	20.27	43.98	41.70	54.58	28.07	43.11

The average results show that the Canadian Beauty gave the highest returns from the heaviest seeding and the O.A.C. No. 181 the highest returns from the lightest seeding. Incidentally it will be noticed the superiority of the O.A.C. No. 181 variety over the Canadian Beauty in yield per acre in each rate of seeding and in each of the three years.

DIFFERENT QUANTITIES OF FLAX SEED PER ACRE

In each of five years four varieties of flax were sown at the rate of one peck, two pecks, three pecks, eight pecks, twelve pecks and sixteen pecks per acre, making in all twenty-four plots in the experiment each year. The following table gives the average results of the experiments for the five year period:—

Amount of Seed Sown	Straw or Fibre-Producing Material		Weight per measured bushel	Yield of Grain per acre	Yield of Grain per acre, less amount of seed sown
	Height of crop	Yield of straw			
	inches	tons	pounds	bushels	bushels
1 peck per acre	29	1.55	54.9	14.9	14.6
2 pecks per acre	29	1.68	54.7	15.2	14.7
3 " " "	29	1.96	54.8	18.6	17.8
8 " " "	28	2.24	54.6	19.9	17.9
12 " " "	27	2.35	54.3	20.2	17.2
16 " " "	26	2.24	54.2	18.0	14.0

It will be seen that the longest straw was produced when less than one bushel of seed per acre was used. It will also be noticed that the greatest yield of straw was produced when two bushels or more were used per acre. It should be remembered that the thin seeding encourages a considerable amount of branching of the stems, while the thick seeding produces straight stems with but little branching.

In the average yield of seed per acre it will be seen that where twelve pecks of seed were used, slightly over twenty bushels of flax seed were obtained. Where the amount of seed used, however, is subtracted from the amount of seed produced, the greatest yield has resulted from eight pecks per acre, which is only slightly more than that obtained from three pecks per acre.

As the results of the experiment here presented show the best general results from three or eight pecks per acre, another experiment was started and has been conducted for five years in succession in which flax was sown at the rates of three, four, five, six, seven and eight pecks per acre. Two varieties were used, namely, the Common and the O.A.C. No. 114, a white flowered variety. This was a double experiment, in the first set the plants were pulled immediately after the blossoms had fallen and the other set was not pulled until the seed was ripe. The following table gives the average results of the two varieties for each of the six rates of seeding for the five-year period in yield of grain per acre and for four years in weight per measured bushel and yield of straw per acre as they apply to each of the two parts of the double test:—

Amount of Seed Sown	Weight per measured bushel (lbs.)	Yield of Straw or Fibre-producing material (tons)	Yield of Grain per acre (bush. by weight)	Yield of Grain per Acre, less amount of seed sown (bush.)
PULLED WHEN BLOSSOMS HAVE FALLEN:				
3 pecks per acre	47.4	2.16	4.83	4.08
4 " "	48.2	1.91	5.03	4.03
5 " "	47.5	1.87	5.05	3.80
6 " "	47.8	1.91	5.19	3.69
7 " "	48.4	2.26	5.37	3.62
8 " "	48.7	2.47	5.94	3.94
PULLED WHEN SEED IS RIPE:				
3 pecks per acre	54.3	1.69	16.88	16.13
4 " "	54.5	1.78	18.72	17.72
5 " "	54.1	2.01	19.47	18.22
6 " "	54.3	2.24	19.72	18.22
7 " "	54.2	2.41	19.04	17.29
8 " "	54.2	2.52	18.26	16.26

The yield of flax seed per acre is only about one-quarter as great when the plants are pulled just as the blossoms have fallen in comparison with those which are allowed to mature. If flax is pulled early for the sake of the fibre the seed, of course, is a secondary matter. Although six pecks of seed sown per acre gives the highest yield of threshed seed from the ripened crop the five-peck seeding gave as high a return when the amount of seed used is subtracted from the crop produced. Taking everything into consideration it would seem that eight pecks per acre for fibre production and five pecks per acre for seed production have shown good returns.

The two varieties used throughout this experiment in which the crop was allowed to ripen gave the following average yearly results: Weight per measured bushel, O.A.C. No. 114, 54.4; Common, 54.1; Yield of straw per acre. O.A.C. No. 114, 2.22; Common, 1.83; Bushels of grain per acre, O.A.C. No. 114, 17.9; Common, 19.5.

PULLING FLAX AT DIFFERENT DATES

In each of five years an experiment was conducted in pulling flax at different dates. The first pulling took place each year when most of the blossoms had fallen and successive pullings at about ten-day intervals. The following table gives the average returns for the five-year period:—

Average date of Pulling	Weight per measured bushel (pounds)	Yield of Flax Straw per acre (tons)	Yield of Flaxseed per Acre (pounds)
July 11	....	1.8	22
" 24	51.0	2.2	377
Aug. 3	53.2	2.2	682
" 15	53.8	2.3	831
" 24	53.4	2.5	826

In seed production the highest returns were obtained from the average pulling of August 15th in both weight per measured bushel and in yield of seed per acre. This would be about thirty-five days after the blossoms had dropped. The results of this experiment along with those of the experiment preceding it give some definite information regarding the relative returns from pulling flax at different stages of maturity, especially from the standpoint of seed production.

SIZE OF SEED AND SEED SELECTION

Good seed is at the very foundation of successful crop production. Seed selection is within the reach of every farmer. Naturally the greatest possible care must be taken but the crop grower is more than paid for his extra effort.

In order to obtain definite results on the influence of different selections of seed it is necessary to plan and carry out definite experimental work and as this is expensive it can be done best at an experiment station where equipment is suitable and trained labour is available.

An interesting and valuable experiment has been carried on at Guelph in which different selections of seed of various classes of grain have been tested from six to nine years. For this experiment seed was taken each year from a general crop of grain grown either on the College farm or in the Experimental Department. It will be understood that whatever difference there is from the influence of the selection of seed that difference is attributed entirely to the careful selection of the seed for the separate years in which the tests were made. The results show the influence of one year's selection, and are, therefore, of special interest to the practical farmer. For the large plump seed none but well-developed grains were selected; for the small plump sample the grains selected were of a uniform character; and for the shrunken sample none but shrunken grains were used, the last selection being made regardless of the size of the kernels. The sample of broken grain in the case of barley, and also of rye, contained nothing but grains which had been broken crosswise; split grain, in the case of winter wheat, contained nothing but grains which were broken lengthwise; and split seed, in the case of peas, contained peas which were split and not broken. The grain from which these selections were made was all threshed with a grain separator, and the splitting and the breaking of the grains were, therefore, done in the usual process of threshing. In the selection of large, plump seed, one-half pound was carefully weighed from each class of grain. The number of large, plump seeds of each kind of grain was then counted, and a corresponding number was taken of the medium sized grain, the small, plump grain, and the shrunken grain. In the case of the broken or split grain, twice the number of half kernels, as compared with the whole grains were used. The different selections were carefully sown upon plots of similar size. The following table gives the average yearly results of each selection made from six different classes of grains:—

Selections	Class of Grain	Years the tests have been repeated	Weight per measured bushel	Average yield per acre per annum	
				Straw (tons)	Grain (bushels by weight)
Large seed	Oats	7	33.2	1.9	62.0
Medium sized seed	Oats	7	32.2	1.8	54.1
Small seed	Oats	7	31.8	1.8	46.6
Large plump seed	Barley	6	49.5	1.5	53.8
Small plump seed	Barley	6	48.8	1.5	50.4
Shrunken seed	Barley	6	49.1	1.4	46.0
Broken seed	Barley	6	48.6	1.3	43.2
Large plump seed	Spring Wheat	8	59.1	1.4	21.7
Small plump seed	Spring Wheat	8	58.3	1.3	18.0
Shrunken seed	Spring Wheat	8	56.9	1.2	16.7
Large plump seed	Winter Wheat	6	59.4	2.6	46.9
Small plump seed	Winter Wheat	6	59.2	2.2	40.4
Shrunken seed	Winter Wheat	6	59.1	2.1	39.1
Split seed	Winter Wheat	6	54.2	.6	9.3
Large seed	Peas	6	56.3	1.3	28.1
Small seed	Peas	6	56.3	1.1	23.0
Sound seed	Peas	9	58.1	1.4	29.2
Split seed	Peas	9	57.9	.6	10.2
Large seed	Spring Rye	6	53.3	2.0	26.0
Medium sized seed	Spring Rye	6	53.3	2.0	24.4
Small seed	Spring Rye	6	53.5	1.9	22.3
Broken seed	Spring Rye	6	52.8	1.6	16.9

These results are of special interest to practical grain growers. It will be seen that only one year's selection of seed grain has a marked influence on the resulting crop. In every instance the large plump seed gave a greater yield of grain per acre than medium sized, small plump, shrunken or broken seed. In the average of the six classes of grain the large plump surpassed the small plump in yield of grain per acre by 18.8 per cent. and in the average of the three classes of grain, namely, barley, spring wheat and winter wheat, the plump seed gave a yield over the shrunken seed of 20.4 per cent. It should be understood that equal numbers of seed were used in this experiment. The results throughout show that a large plump seed will produce a larger, more vigorous and more productive plant than that produced from a small plump or from a shrunken seed. The results point in a very striking manner to the great importance of removing small plump, shrunken, broken and split grain from seed to be used for sowing. With fanning mills and graders which are made at the present day the separations can usually be made with a large amount of satisfaction. Enterprising farmers are now making use of personally owned graders or are taking advantage of mills or graders which serve the community. In the future a greater attention should be given to this important matter than it has received in the past.

SINGLE OAT SEED SELECTION

When the writer was in the city of Washington a few years ago attending a meeting of the American Society of Agronomy, an interesting discussion took place regarding the influence of the size of seed on crop production. He regretted the fact that so little had been done at any experiment station to show the influence of the size of the seed when the seeds were placed at different distances apart. On returning to the College he followed his own advice to others and started an experiment to glean information along the lines suggested. The oat crop was selected as it is the most important in Ontario and it is comparatively easy to secure large and small plump seed. The experiment was conducted between 1909 and 1915 but the results have not been published before as this problem was connected up with other experiments of a more recent date. This test was conducted for six years and was repeated with four varieties of oats each season. Large sized and small sized oats of each variety were compared each year at each of seven different rates of planting. The small oats were about two-fifths the size of the larger ones. The seed of both selections was planted in squares. The distances between the squares being one, two, three, four, six, eight and twelve inches. It will, therefore, be seen that the thickest planting would have 144 more seeds than the thinnest planting on the same area. The planting had to be done by hand as great accuracy was essential. At harvest time outside plants of all plots were discarded. As nearly as plantings would permit, the plots were about ten links square and the yields were determined in accordance with the size of the plots. This six years' experiment has required no less than three hundred and thirty-six plots of oats. The following table gives important average results from planting large seed oats and small seed oats in squares at different distances apart over a period of six years:—

Distance between oats planted in squares (inches)	Comparative amount of rust on straw		Weight per measured bushel (lbs.)		Yield of grain per acre (bus.)	
	Large seed	Small seed	Large seed	Small seed	Large seed	Small seed
1....................	10	13	33.0	32.8	36.38	36.16
2....................	11	15	35.6	34.6	45.89	44.25
3....................	14	17	34.5	33.3	53.08	50.04
4....................	16	19	32.8	31.5	50.22	45.78
6....................	20	22	30.9	29.2	48.35	40.38
8....................	22	25	29.4	26.6	40.52	34.11
12....................	26	30	26.6	24.1	27.71	23.20

As the selections of large and small oats were not continuous from one year to another but were made from samples which had not been previously selected, it will be seen that the average of six years' results show the influence which might be expected in an average season.

The average results show, without an exception, that there was more rust from small than from large seed also that in both cases the amount of rust increased as the distance between the plants increased. It will be seen that the straw of the plants which were grown the farthest apart had more than twice as much of their surface covered with rust as those which were grown closest together. This applies to the plants grown from both the large and the small seed. The lowest percentage of rust was on plants from the large seed planted close together and the largest amount on the plants produced from the small seed planted at the greatest distance apart.

In every instance the average weight per measured bushel was greater from the large than from the small seed. This difference was most noticeable with the plants grown wide apart.

The large seed produced a greater average yield of grain per acre than the small seed in each of the seven thicknesses of planting. The greatest difference was shown when the plants were grown six inches apart each way when the large seed gave an average of 19.8 per cent. more than the small seed. When the plants were grown one inch apart each way the comparative influence of the large and small seed was the least marked.

As all the results here tabulated are the averages of twenty-four tests for rust and yield of grain and of twenty tests for weight of grain per measured bushel and as they were conducted over a variety of seasons and on soil which might be termed an average clay loam they are worthy of careful and thoughtful consideration by both farmers and experiment station workers.

Continuous Selection of Heavy and Light Oats for 32 Years

An experiment has been conducted continuously for the thirty-two years, from 1894 to 1926, in selecting heavy and light seed of the Joanette variety of oats. The heavy seed used was large, plump with black kernels and the light seed was lighter in weight and the hull was usually a pale black. The main oats were used throughout. The selection made in each year was from the product of the selected seed of the year previous. The seed for each plot in each year was composed of an equal number of grains which were sown on uniform plots each twenty-five links square.

The main object in this experiment was to ascertain whether or not continuous selection would gradually widen the difference in yield per acre of the two selections. In dividing the thirty-two years from 1894 to 1926 into two periods, we find that the increase in the yield per acre from the heavy seed as compared with the light seed was 26.94 per cent. for the first period of sixteen years and 26.92 per cent. for the second period of sixteen years. The per cent. increase from the large over the small seed in 1894 was 32.22 and for the whole period of thirty-two years 26.93. This bears out other experiments and shows that the size of seed has a marked influence on the first crop but practically no additional influence through continuous selection. Selection of seed, therefore, is of more importance to the practical farmer than to the plant breeder. In many varieties of farm crops, however, there are often variations caused by natural cross-fertilizations or possibly by mutations which may be selected to great advantage through the nursery plot system where all varieties can be grown and compared under uniform conditions.

TESTING SEED OATS AFTER THE HULL HAS BEEN REMOVED

In connection with the foregoing experiment a selection of oats of the Joanette variety from which the hulls had been removed in the threshing was made in each of thirty-two years. The average results for the whole period show that large, plump black oats from which the hulls had not been removed gave 63.8 bushels of grain per acre and 33.0 pounds per measured bushel while the oats from which the hulls had been removed gave an average of 57.3 bushels per acre and a weight of 34.6 pounds per measured bushel. Therefore, the oats from which the hulls had been removed during threshing gave a less yield per acre but a greater weight per measured bushel than the choice oats which still remained in the hull. In twenty-two out of twenty-three years the normal oats gave the highest yield and in nineteen out of the thirty-two years the hulled oats came highest in weight per measured bushel. We can readily understand that the hulled oats in practically all cases would come from those kernels which were ripest, plumpest and thinnest in the hull. As the results show that these hulled oats have made a comparatively good report when compared even with a large, plump unhulled seed it shows that a few hulled kernels in seed oats does not very seriously injure the grain for seed purposes. Generally speaking, however, it is wise to use large, plump oats in the normal condition of having their hulls on when the material is required for the purpose of seeding.

SIZE OF BEANS FOR SEED

In 1923 an experiment had been conducted for six years in the testing of beans of different selections. In each year two varieties of beans were used, namely, the Pearce's Improved Tree and the American Wonder. Large, medium, small and very small seed was selected from each variety. These were planted under as near uniform conditions as possible. The plots were equal in size and the beans were placed at equal distances apart in the rows. The following table gives the average results for the six-year period:—

Selections	Class of Grain	Weight per measured bushel (lbs.)	Average yield per acre per annum	
			Straw (tons)	Grain (bushels by weight)
Large	Beans	63.9	.8	18.7
Medium	Beans	64.0	.7	17.8
Small	Beans	64.2	.7	14.4
Very Small	Beans	63.9	.6	9.3

It will be noticed that as the size of the seed decreased so did the average yield of beans per acre. The large beans gave fully double the yield of that produced from the very small.

SIZE OF CORN SEED

In 1920 an experiment had been conducted for six years in testing large, medium and small kernels of corn when used for seed. Two varieties were used each year, namely, the Compton's Early Yellow Flint and the White Cap Yellow Dent. The plots were uniform in size and an equal number of kernels of corn of each selection was planted each season. In order to avoid blanks two kernels were planted together and after the plants had made a small growth they were thinned to single plants. The following table gives the average results of the twelve tests conducted in a six-year period:—

Selections	Class of Grain	Yield per acre	
		Total green crop (tons)	Shelled grain (bushels)
Large	Corn	14.1	35.0
Medium	Corn	14.0	33.4
Small	Corn	12.9	30.7

The size of seed has an influence on the crop produced in corn as it has in the other grain crops previously reported.

Seed Wheat Injured by Sprouting at Harvest Time

In each of two years when winter wheat was sprouted in the fields, germination tests of the grain were made. The following results show the average percentage of germination from each selection: skin over germ, unbroken, 94; skin over germ, broken, 76; sprouts one-quarter inch long, 30; and sprouts one inch long, 18. Not only were the sprouted seeds low in germination, but the plants produced were very uneven in size.

Sowing Spring Grain Broadcast and with a Grain Drill

For five years in succession, oats, barley, spring wheat and peas have been sown both broadcast and with a grain drill on each of six different dates. We have, therefore, made one hundred and twenty separate tests in comparing these two methods of sowing. The soil for this experiment was always well cultivated and received exactly the same treatment for each method of sowing. The same amount of seed was used for sowing broadcast as for sowing with a grain drill.

The average yields of grain produced from the two methods of sowing are as follows: Oats—drilled, 53.4 bushels; broadcast, 50.8 bushels. Barley—drilled, 36 bushels; broadcast, 34.7 bushels. Spring wheat—drilled, 13.2 bushels; broadcast, 13.4 bushels. Peas—drilled, 23.1 bushels; broadcast, 21.8 bushels. As these averages include the results from sowing at six different dates in the spring, the yields are not so high as if the results of the latest seedings had not been included. By comparing the two methods of sowing the four grains on six different dates and in five separate years, we find that the grain which was sown with the grain drill gave 1.28 bushels per acre more than the grain which was sown broadcast with the hand.

Sowing Winter Wheat Broadcast and with a Grain Drill

Starting in 1920 and continuing until 1926 an experiment has been conducted in sowing winter wheat broadcast and with a grain drill. The experiment was conducted with the O.A.C. No. 104 variety in the six years from 1920 to 1925 and with the Dawson's Golden Chaff (O.A.C. No. 61) in 1926. The test was repeated eleven times each year. This experiment, therefore, required one hundred and fifty-four plots in the seven-year period. The average records for the seven years for each of the two methods of seeding are as follows:—

Method of seeding	Height of crop (inches)	Per cent. rust	Per cent. lodged	Weight of grain per measured bushel (pounds)	Yield per acre	
					Straw (tons)	Grain (bushels by weight)
Drilled................	41.07	8.01	11.05	58.98	2.14	39.85
Broadcast.............	40.58	8.68	9.08	57.55	1.92	36.72

In practically all respects the drilled grain gave better returns than that which was broadcasted. There was, however, a slightly higher percentage of lodging from the grain which was drilled. This might be expected owing to the fact that there was a heavier yield of grain for the straw to support.

SOWING WINTER RYE BROADCAST AND WITH A GRAIN DRILL

An experiment has been conducted for the five years from 1922 to 1926 inclusive, in which winter rye was sown broadcast and with a grain drill. The experiment was conducted with the Petkus winter rye in 1922 and 1923, and with the Rosen variety in each of the past three years. The test was repeated six times each year, thus making thirty separate tests or sixty plots in all. The average annual records for the five years are given in the following table:—

Method of Seeding	Weight of grain per measured bushel (lbs.)	Yield per acre	
		Straw (tons)	Grain (bushels by weight)
Drilled....................................	55.8	2.81	52.35
Broadcast.................................	55.3	2.70	50.33

The results show somewhat better returns throughout from the drilled as compared with the broadcast seeding with winter rye.

METHODS OF SOWING SOY BEANS

In each of the three years, 1924-1926 inclusive, an experiment has been conducted in sowing the Early Brown and the O.A.C. No. 211 varieties of soy beans broadcast, with an ordinary grain drill, and in rows 26.4 inches apart. For each of the methods referred to, each variety was sown at the rates of one-half, one, one and one-half, two and two and one-half bushels of seed per acre. Ninety plots have, therefore, been used in the experiment up-to-date.

The following table is the average results of the two varieties for the three-year period:—

Seed per acre (bushels)	Broadcast		Drills—7.92 inches apart		Rows—26.4 inches apart	
	Straw (tons)	Grain (bushels by weight)	Straw (tons)	Grain (bushels by weight)	Straw (tons)	Grain (bushels by weight)
2½	1.44	23.98	1.58	27.73	1.54	25.59
2	1.48	23.30	1.67	26.21	1.51	25.55
1½	1.49	24.15	1.65	26.94	1.51	25.20
1	1.36	23.67	1.56	26.30	1.48	25.29
½	1.14	19.26	1.51	24.22	1.42	25.54

The average results show that sowing with a grain drill gave 26.28; sown in wide rows, 25.43; and sown broadcast, 22.89 bushels of grain per acre. When the wide rows are used even a half bushel of seed gives over 25 bushels per acre and this amount is not materially increased even up to two and one-half bushels per acre. In both of the other methods, however, a heavier rate of seeding gives higher returns; but of these two methods, one bushel of seed per acre whether sown with a grain drill or sown broadcast gives about the best results if we subtract the amount of seed used from the crop produced.

In averaging the results of the different rates of seeding in the different years it is found that the O.A.C. No. 211 surpassed the Early Brown variety in annual yield per acre by 5.73 bushels from the broadcast seeding, 9.03 bushels from the grain drill seeding and 7.98 bushels from the seeding in the wide rows.

SOWING FOUR SPRING GRAINS AT DIFFERENT DATES

Some time ago an experiment was conducted at the College for five years in succession in sowing spring wheat, barley, oats and peas at six different dates in the spring, commencing as early as the land could be worked satisfactorily and allowing one week between each two dates of sowing. The varieties of grain used in this experiment were Herison Bearded and Pringle's Champion spring wheat. Mandscheuri and Kinna Kulla barley, Siberian, Oderbrucker, and Waterloo oats, and Early Britain and White Wonder peas. In each year the experiment was conducted in duplicate by sowing one plot at each date of seeding with the grain drill and another plot broadcast by hand. The result from the two methods were averaged each year. It will, therefore, be seen that there were ten separate tests in this experiment. The average results of the ten distinct tests conducted in the five-year period are as follows:—

Dates of seeding	Yield of straw per acre (tons)				Weight of grain per measured bushel (pounds)				Yield of grain per acre by weight (bushels)			
	Spring Wheat	Barley	Oats	Peas	Spring Wheat	Barley	Oats	Peas	Spring Wheat	Barley	Oats	Peas
First	1.2	1.2	2.0	.9	60.1	52.3	33.9	56.6	21.9	46.2	75.2	25.4
Second	1.1	1.2	2.1	1.1	59.6	52.6	34.5	56.6	19.2	45.9	76.0	28.8
Third	1.0	1.1	1.8	1.1	59.0	51.8	32.1	57.6	15.4	39.8	64.2	28.5
Fourth	.9	1.0	1.7	1.0	58.9	50.3	29.9	57.4	13.0	37.1	55.8	25.5
Fifth	.6	.9	1.6	.9	56.5	48.2	27.3	57.0	8.4	27.6	45.2	21.5
Sixth	.8	.9	1.7	1.0	54.0	45.1	24.2	57.0	6.7	18.4	35.0	19.5

The dates of starting and closing the test varied in different years according to seasonal conditions. The average dates of sowing were as follows: first, April 18th; second, April 24th; third, May 2nd; fourth, May 10th; fifth, May 17th; sixth, May 25th.

It will be seen that the best results were obtained from sowing both spring wheat and barley as soon as the land was in proper condition for cultivation in the spring. With oats it mattered but little whether seeding took place at the beginning or the end of the first week on which the land could be worked satisfactorily. The results from the tests with peas, however, show that the best returns were obtained from the second date of seeding, and that even the fourth date gave as large a yield of both grain and straw per acre and as high a weight of grain per measured bushel as was obtained from the first seeding. These results show the importance of sowing very early in the spring and in the following order: spring wheat, barley, oats and peas.

It is interesting to note that there was a gradual decrease in crop production as the dates advanced from the beginning to the end of the test. According to the results of the experiment, there was an average decrease in yield per acre of twenty-seven pounds of spring wheat, forty-seven pounds each of barley and of oats, and of twenty pounds of peas for each day's delay. It is, therefore, essential, if the best results are to be obtained, to sow these spring grains very early in the spring.

SOWING FIVE SPRING GRAINS AT DIFFERENT DATES

Another experiment was started in 1918 and concluded in 1922 in which definite and special varieties were sown at each of six different dates, in each of the five years. The experiment was conducted in duplicate throughout, thus making use of a total of three hundred plots. The same varieties were used throughout the experiment. Seed was sown broadcast each year. In the case of oats two varieties were used, one late and the other early. The following table gives the average results for the five-year period:—

Dates of seeding	Yield of straw per acre (tons)					Weight of grain per measured bushel (pounds)					Yield of grain per acre by weight (bushels)				
	Marquis Wheat	O.A.C. No. 72 Oats	O.A.C. No. 3 Oats	O.A.C. No. 61 Rye	Common Flax	Marquis Wheat	O.A.C. No. 72 Oats	O.A.C. No. 3 Oats	O.A.C. No. 61 Rye	Common Flax	Marquis Wheat	O.A.C. No. 72 Oats	O.A.C. No. 3 Oats	O.A.C. No. 61 Rye	Common Flax
First	1.4	1.7	1.4	1.8	1.8	60.1	31.7	33.3	54.5	53.1	23.3	71.2	66.5	29.1	21.4
Second	1.4	1.8	1.4	1.7	2.0	58.5	31.0	32.8	54.0	53.3	21.0	67.6	67.2	26.6	21.7
Third	1.4	1.8	1.5	1.7	2.1	58.0	31.0	32.3	52.9	53.4	19.9	64.0	66.7	23.8	21.4
Fourth	1.3	1.8	1.6	1.6	2.1	57.1	29.6	31.3	53.1	53.4	18.3	59.1	66.8	22.3	20.2
Fifth	1.1	1.8	1.5	1.4	2.1	55.5	28.7	30.1	52.5	53.5	15.6	51.9	61.8	18.2	19.5
Sixth	.9	1.7	1.4	1.1	2.0	....	24.2	27.9	50.2	53.6	9.8	36.2	47.0	11.8	15.1

As in the case of the former experiment the dates of starting and closing the test varied in different years according to seasonal conditions. The average dates of sowing were as follows: first, April 14th; second, April 22nd; third, April 29th; fourth, May 6th; fifth, May 15th; and sixth, May 20th. It will be seen that the dates were four or five days earlier throughout than they were for the previous experiment. This experiment again shows the great importance of sowing spring wheat very early in the season. For late oats there is a gradual decrease from the first to the last date of seeding. In the case of early oats, however, the results are quite different. The second date gave the highest yield and there was but little difference in yield per acre from the first four dates. This is excellent information. It will be noticed that from the first date of seeding the O.A.C. No. 72 surpassed the O.A.C. No. 3 by 4.7 bushels per acre. In the fourth date of seeding, however, the reverse took place as the O.A.C. No. 3 gave 7.7 bushels per acre more than the O.A.C. No. 72. On the average of May 20th the early oats gave 10.8 bushels per acre more than the late variety. It seems decidedly preferable, therefore, to sow late oats very early in the spring and early oats if the seeding takes place late in the season.

As in the case of spring wheat, spring rye responds best to very early seeding.

There is but little difference in seed production in flax from the first three dates of sowing. In amounts of fibre, however, the yield is fairly constant throughout. In fact, the earliest date gave the smallest yield per acre.

DATES OF SOWING EMMER AND SPELT

Emmer and spelt are used in some countries to a limited extent for flour production. When used for this purpose, however, special machinery is required for separating the chaff or the hull from the grain, as the grain is usually surrounded by the chaff after being threshed. In this country these grains are considered from the standpoint of the amount of feed which they will produce for farm stock. Emmer is about equal to barley for feeding purposes.

In each of five years both emmer and spelt were sown on eight different dates in the spring, by making the first date in the season as early as the land was suitable for cultivation. One week was allowed between each two dates of seeding. The Common Emmer and the Red Spelt were the special varieties used. The average results of the experiment for five years are presented in the following table:—

Dates of seeding	Yield of straw per acre (tons)		Weight of grain per measured bushel (pounds)		Yield of grain per acre (pounds)	
	Spelt	Emmer	Spelt	Emmer	Spelt	Emmer
First	1.6	1.9	28.3	40.1	2,377	2,747
Second	1.6	2.0	27.3	39.1	2,163	2,848
Third	1.7	2.0	26.3	39.1	1,898	2,646
Fourth	1.6	2.1	24.9	37.6	1,582	2,754
Fifth	1.5	2.1	24.2	36.7	1,287	2,569
Sixth	1.6	2.3	21.6	36.1	933	2,465
Seventh	1.5	2.4	19.6	35.4	685	2,312
Eighth	1.5	1.9	19.9	34.0	499	1,953

The figures representing the pounds per measured bushel and the pounds of grain per acre include the chaff or hull surrounding the grain, as well as the grain itself. In the examination of the results here presented, the reader will be impressed with the superiority of the emmer as compared with the spelt in weight of grain per measured bushel, and in yield of both straw and grain per acre. In no instance does the spelt show a better record than the emmer. It will be noticed that even the fourth seeding of emmer produced a higher yield of grain per acre than that obtained from the first seeding. The results, from this and the preceding experiment, seem to indicate that emmer may be sown at a later date than other classes of spring grain.

SOWING WINTER WHEAT AT DIFFERENT DATES

An experiment has been conducted for seven years from 1920 to 1926, inclusive, in which winter wheat was sown on each of eleven different dates starting on the 26th of August and allowing one week between each two dates of seeding. The experiment was conducted with two varieties, namely, the O.A.C. No. 104 and the Dawson's Golden Chaff (O.A.C. No. 61). One set of each variety was sown broadcast and another with the grain drill. It will, therefore, be seen that three hundred and eight plots have been used for this experiment up to date. The following table gives the average results of the experiment for the seven-year period:—

Dates of seeding	*Dates of maturity	Height of crop (inches)	Per cent. rust	Per cent. lodged	Weight of grain per measured bushel (pounds)	Yield per acre	
						Straw (tons)	Grain (bushels by weight)
Aug. 26	July 24	45	3	11	61.86	2.84	57.84
Sept. 2	" 24	45	3	17	61.61	3.03	58.86
" 9	" 25	44	4	16	61.54	2.91	57.87
" 16	" 25	44	5	10	61.54	2.71	57.75
" 23	" 27	43	5	12	61.33	2.49	51.85
" 30	" 29	41	8	8	60.59	2.03	40.62
Oct. 7	Aug. 2	40	11	9	58.77	1.77	31.35
" 14	" 7	38	13	7	55.98	1.36	22.32
" 21	" 9	37	14	8	54.11	1.23	16.59
" 29	" 10	37	14	8	*53.84	*1.01	*12.71
Nov. 5	" 10	36	14	7	*53.46	.98	11.89

*Average of six years only.

The highest average yields of both grain and straw per acre were produced on September 2nd. These, however, were followed quite closely by those of August 26th and September 9th. There was a decided average decrease after September 16th.

In connection with these results it might be mentioned that in each of five years there was more or less trouble from hessian fly. It will be seen from the accompanying results that the average seeding of September 23rd was about six bushels per acre less than those of September 16th and this reduction from the later seeding took place in spite of the fact that the hessian fly was present and did its work in the harvests in each of the five years, 1920, 1921, 1922, 1923 and 1924. In the last two years there has been no trace whatever of damage from the hessian fly. In every one of the seven years the highest yields were obtained from the four earliest dates of seeding. In 1922, when the hessian fly caused the greatest damage, the highest yield of wheat was produced from the seeding of September 16th, and in 1923, when the fly caused the next greatest damage, the highest average yield of grain was produced by the seeding of September 9th. In 1925 the highest yield was from the seeding of August 26th, and in 1926 from September 2nd.

In Bulletin No. 140 giving results of field experiments with farm crops and issued in 1905, the following sentence occurred on page 21: "Winter wheat sown at the College during the first ten days of September in each of nine years has yielded 5.2 bushels per acre more than that sown from the 16th to the 20th of September." It will, therefore, be seen that the experiments with dates of seeding of winter wheat have been conducted at the College for sixteen years and the results are overwhelmingly in favour of sowing at the end of August or in the first nine or ten days of September.

Sowing Winter Rye at Different Dates

Starting in 1922 and continuing in each of the past five years, an experiment has been conducted in sowing winter rye on each of six different dates, starting on August 26th and allowing two weeks between each two dates of seeding. The Petkus rye was used in the experiments in 1922 and in 1923 and the Rosen in the tests in each of the last three years. The experiment was conducted in duplicate, one set being broadcasted and the other sown with the grain drill. The following gives the average of the ten tests conducted in the five-year period:—

Dates of seeding	Dates of maturity	Height of crop (inches)	Per cent. rust	Per cent. lodged	Weight of grain per measured bushel (pounds)	Yield per acre	
						Straw (tons)	Grain (bushels by weight)
Aug. 26	July 23	59	2	14	57.15	3.63	65.33
Sept. 9	" 23	59	3	15	56.53	3.72	65.49
" 23	" 24	58	4	5	56.63	3.16	60.36
Oct. 8	" 31	53	5	8	55.85	2.34	47.18
" 21	" 31	49	6	12	54.38	1.92	37.95
Nov. 4	Aug. 1	47	8	17	53.48	1.73	31.74

It is generally understood that winter rye will stand later seeding than winter wheat. As rye is a hardier crop than winter wheat it is quite possible that in the adverse conditions of late seeding, rye might do better than winter wheat under exceptionally trying conditions. In the average of five years' results, however, it will be seen that in yield of grain per acre the winter rye which was sown on September 9th gave a higher yield per acre than any of the four later seedings when two weeks were allowed between each two dates of seeding. It will be noticed, however, that the seeding even as late as November 4th gave almost a half yield of grain while the winter wheat sown as late as November 5th gave less than one-fifth the yield per acre as compared with that sown on September 2nd. A comparison of the results of the different dates of sowing winter rye and of winter wheat as here presented forms an interesting study.

Planting Corn at Different Dates

From 1919 to 1925, inclusive, an experiment was conducted in planting each of three varieties of corn on each of five different dates starting on May 9th and finishing on June 6th. The experiment was conducted in duplicate each year. In the autumn of each year the crops on all the plots were cut on the same day. The whole crop was weighed immediately in its fresh condition. The ears were husked and when properly dried the grain was shelled and weighed. As the total weights of the green corn contained varying amounts of moisture the results are not so valuable as the weight of the ripened and dried shelled corn. The following table gives the results of the twelve separate tests conducted with each of the three varieties for the six-year period:—

Date of planting	Yield of grain per acre (bushels)			
	Longfellow	Golden Glow	White Cap Yellow Dent	Average of 3 varieties
May 9	57.18	55.36	60.81	57.78
" 16	56.11	60.67	63.79	60.19
" 23	52.70	59.87	57.99	56.85
" 30	39.03	43.83	44.71	42.52
June 6	24.21	24.39	24.45	24.35

The Golden Glow and the White Cap Yellow Dent each gave the highest results from the planting of May 16th and the second highest from the planting of May 9th, while the Longfellow gave the highest from the earliest and the next highest from the second date of planting. As the date of planting advanced from May 16th there was an average decrease in yield of grain per acre in each of the three varieties and these decreases were decidedly marked.

Dates of Seeding Soy Beans

Each of three varieties of soy beans has been sown under experiment at the College on four different dates starting on May 8th and finishing on May 28th, allowing practically a week between each two dates of seeding. The experiment was conducted for the three years, 1924-25-26. The following table gives the average results of the three years' test as applied to each of the three varieties planted on four separate dates:—

Date of seeding	Early Brown		Early Yellow		O.A.C. No. 211	
	Date of maturing	Yield of grain per acre (bush.)	Date of maturing	Yield of grain per acre (bush.)	Date of maturing	Yield of grain per acre (bush.)
May 8	Sept. 25	22.30	Sept. 26	24.14	Oct. 6	27.02
" 14	" 27	22.85	" 26	22.98	" 8	27.91
" 21	" 29	21.34	" 28	21.93	" 9	25.07
" 28	Oct. 2	22.09	" 30	21.83	" 9	23.19

According to the results of this experiment, three years of which have already elapsed, we learn that the highest average yield of soy beans per acre was obtained from the average date of seeding of May 8th. This is considerably earlier than the date on which ordinary field beans are usually planted in Ontario, the common date for the latter being the first week or ten days in June. In 1924 and in 1925 each of the three varieties were also planted on April 24th and May 1st, and the results were slightly higher than are shown here for May 8th. In 1926, however, owing to unfavourable weather conditions satisfactory plantings could not take place on the two dates referred to. It is important in sowing soy beans, especially a large vigorous producer like the O.A.C. No. 211, to get the seed in comparatively early, usually about the first week of May.

The Growing of Mixed Grains in Ontario

The Ontario Department of Agriculture has collected statistics regarding Ontario's crop production continuously since 1882. It was not, however, until 1907 that statistics were collected regarding the acreage and the production in Ontario of grains grown in combination. Probably owing to the results of experiments conducted at the College and to the practical experience of the farmers themselves, there has been a steady increase in the acreage devoted to grains grown in combination, particularly oats and barley. In 1926 no less than 770,981 acres were devoted to mixed grains. This was a larger acreage than in any previous year.

According to the reports of the Statistics Branch of the Ontario Department of Agriculture for the seventeen years from 1909 to 1925, inclusive, for which information has been furnished, we learn that the average market value per acre per annum for the province was $19.01 for oats, $23.14 for barley, and $25.73 for mixed grain. It will, therefore, be seen that grains grown in combination are valued considerably higher than either oats or barley when grown separately. In bushels per acre for the twenty years for which information is furnished, we find that there was an average annual yield in bushels per acre of 30.08 for barley, 35.81 for oats, and 36.36 for mixed grain. When we realize that the weight per bushel of mixed grain would be considerably higher than that of oats we learn that not only has mixed grain given the highest yield in bushels per acre, but has also given the highest yield in actual pounds of grain per acre.

Probably more experimental work has been done at Guelph in testing grain mixtures than in any other place in America, or at all other stations combined. Although much interest has been taken in the results of our experiments at the College in both Canada and the United States, it seems rather strange that so little real investigation has been accomplished along this line in other centres. It is probably true also that a greater acreage is now devoted to the growing of grains in combination in Ontario than in any other province or in any state of the American Union. The results of experiments here presented, many of them of very recent date, should be of much interest not only to the people of Ontario, but also to those outside of the province.

Twelve Kinds of Grain Grown in Combination

In the spring of 1902, an experiment was started in growing twelve kinds of grain in different combinations. One of the principal objects of this experiment was to learn which of twelve different kinds of grain would produce the greatest percentage of grain in the crop produced. The mixtures were made up in two different ways: first, by using the same amount of seed of each variety as is usually sown when the grains are grown separately; and second, by using equal quantities of seed of all the varieties. Each of the mixtures here described was sown at the rate of 112 pounds of seed per acre. Both parts of the experiment were conducted in duplicate each year. The following table gives the average results of two tests in each of six years, and shows the percentage of each grain in the crop produced from each of the methods of combination indicated above.

The comparative value of the different classes of crops for growing in mixtures is quite clearly shown in the tabulated results of six years' experiments here presented. It will be seen at once that there is a somewhat higher percentage of six-rowed barley in the product of both mixtures than of any of the other grains.

Varieties used in each mixture	Percentage of grains in mixture		
	Uniform weights of seed sown 6 years 12 tests	Quantities of seed in same proportion as when grown separately 6 years 12 tests	Average of two classes of mixtures 6 years 24 tests
Six-rowed Barley (Mandscheuri)	18.1	17.1	17.6
Spring Rye (Common)	13.3	14.1	13.7
Hulless Barley (Black	12.5	14.2	13.3
Early White Oats (Alaska)	12.7	9.4	11.0
Black Oats (Joanette)	11.9	8.6	10.2
Emmer (Common)	7.0	7.9	7.5
Hulless Barley (White)	5.8	6.9	6.3
Peas (Field)	4.4	7.6	6.0
Spring Wheat (Wild Goose)	4.8	6.3	5.6
Grass Peas	5.6	4.7	5.2
Vetches (Common)	2.3	1.9	2.1
Flax (Common)	1.8	1.3	1.5

EIGHT KINDS OF GRAIN GROWN IN COMBINATION

Based on the results of the test in sowing twelve grains in combination, another experiment was started in 1907, the same year in which the former test was concluded. The new experiment embraced eight instead of twelve classes of farm crops by dropping the lowest three and using one instead of two varieties of oats. It has continued for twenty years.

As it was important to have included in this experiment a prominent and leading variety of each class some of the kinds have been changed in order to keep the experiment up-to-date. For the period from 1907-1914 the following varieties were used: six-rowed barley, Mandscheuri; oats, Banner; spring wheat, Red Fife; durum spring wheat, Wild Goose; emmer, Common; spring rye, Dakota Mammoth; hulless barley, Guy Mayle; field peas, Early Britain. In the period from 1915-1924 the same varieties were used, excepting in six-rowed barley, Mandscheuri was supplanted by O.A.C. No. 21; in oats, Banner by O.A.C. No. 72; and in spring rye, Dakota Mammoth by O.A.C. No. 61. In the two-year period, 1925-1926, the O.A.C. No. 72 variety of oats was changed to O.A.C. No. 144; the Red Fife spring wheat was changed to O.A.C. No. 85, and Early Britain field peas to O.A.C. No. 181. The experiment was repeated four times each year by having duplicate tests of each of two sets of mixtures. The mixture for set 1 was made up of uniform weights of seed of the different crops, and the mixture for set 2 was made up by having the seed of the different classes in the same proportions which are usually sown when the different crops are used in ordinary farm practice. It will be seen that this method is the same as was used for the former test. The mixtures were sown at the rate of 112 pounds of seed per acre in all instances.

When the grain from each set of the two combinations was harvested each year the eight different classes of crops were carefully separated, weighed, and the percentage of each accurately determined.

The following table gives the average percentages of the different crops for each proportion of seeding for each of the periods in which the experiment was conducted with uniform varieties, also the average results for all tests conducted in the twenty-year period:—

Varieties	Percentage of grain produced in the mixed crop									
	8 years 1907–1914			10 years 1915–1924			2 years 1925–1926			Average of all tests for the 20-year period
	Set I	Set II	Ave. 2 Sets	Set I	Set II	Ave. 2 Sets	Set I	Set II	Ave. 2 Sets	
Six-rowed Barley........	24.9	23.5	24.2	22.7	20.9	21.8	23.2	20.4	21.8	22.76
Oats....................	17.7	11.8	14.8	18.6	12.5	15.5	12.5	8.5	10.5	14.76
Spring Rye.............	13.7	14.1	13.9	14.4	14.6	14.5	17.0	16.7	16.8	14.49
Spring Wheat...........	10.8	11.8	11.3	9.3	9.8	9.6	18.4	18.4	18.4	11.02
Hulless Barley..........	11.6	12.1	11.9	9.7	10.9	10.3	9.5	10.1	9.8	10.85
Field Peas..............	4.7	6.7	5.7	11.9	15.6	13.7	3.5	6.5	5.0	9.62
Emmer..................	10.2	11.5	10.9	7.9	8.6	8.3	8.7	10.1	9.4	9.51
Durum Spring Wheat....	6.6	8.7	7.7	5.4	7.3	6.4	7.2	9.2	8.2	7.08

If all grains had the same proportion in the crops produced as in the amount of seed sown, each would have about twelve per cent. Especially would this be true in set 1, where exactly equal weights of the grain of eight different classes of farm crops were sown in combination. The tabulated results here presented, however, show marked variations in the percentage of crop produced as compared with the seed sown. Barley, in no instance, gave less than twenty per cent. of the whole crop, while the durum spring wheat which was the Wild Goose variety, in no instance, gave as high as ten per cent. Barley gave the highest proportion not only in the averages for several years, but also in every individual test throughout the whole twenty-year period. Barley has a wonderful power of high production whether sown alone or in any sort of combination in which it has been included. Oats and spring rye when grown in the combinations produce quite similarly. In most instances, the three crops, barley, oats and rye, gave higher than the 12½ per cent. while the other five crops came lower. The durum or Wild Goose spring wheat was uniformly very low. These results are interesting in connection with the whole problem of growing different classes of grain in combination, to not only farmers but to investigators. As the basis of these tests we have conducted other lines of investigation, the results of which will be presented in this bulletin.

FOUR GRAINS GROWN IN MIXTURES FOR GRAIN PRODUCTION

For six years in succession a very interesting experiment was conducted by growing barley, oats, spring wheat and peas separately and in various combinations for the production of grain and straw. Six mixtures having two classes of grain in each mixture, four having three classes of grain in each mixture, and one having all four classes of grain in combination were used each year. This would make in all eleven mixtures, besides the four grains grown separately, forming in all fifteen plots. This experiment was conducted in duplicate, thus making thirty plots each year, or one hundred and eighty plots in the six years.

The following table gives the comparative results of the same kinds of grain grown on equal areas separately and in combination in the six-year period.

It will be seen that with but one exception the grains grown in combination gave higher results than the same grains when grown separately. For instance, when oats and barley were grown together they gave a higher yield than was produced on an equal area, one-half of which was used for pure oats and the other half for pure barley. In the individual years the mixture of barley and oats came higher in each of four and second highest in the other two.

Mixtures	Yield per acre			
	Straw (tons)		Grain (pounds)	
	Grown separately	Grown in combination	Grown separately	Grown in combination
Oats and Barley	1.56	1.74	1,935	2,261
Oats, Barley and Peas	1.47	1.67	1,849	2,101
Oats, Barley and Wheat	1.47	1.72	1,683	2,067
Oats and Peas	1.52	1.77	1,873	1,988
Oats, Barley, Peas and Wheat	1.43	1.71	1,682	1,955
Oats and Wheat	1.52	1.68	1,624	1,921
Oats, Peas and Wheat	1.44	1.73	1,642	1,860
Barley and Peas	1.33	1.56	1,740	1,760
Barley, Peas and Wheat	1.32	1.57	1,553	1,665
Barley and Wheat	1.33	1.41	1,491	1,558
Peas and Wheat	1.29	1.37	1,429	1,322

The foregoing results show that a mixture of barley and oats gave an average of 2,261 pounds of grain, and that a mixture of peas and wheat gave a yield of only 1,322 pounds or a yield of 939 pounds of grain less than that produced by the mixture of barley and oats.

In yield of straw per acre in the average of the six years' experiments the peas and oats produced the greatest yield.

From the general results it appeared that when grown in combination, barley and oats exert the greatest and peas and wheat the smallest influence in the resulting crop.

When a comparison is made between the different grains grown separately and the same grains grown in mixtures, it was found in about ninety per cent. of the experiments that the mixtures produced a larger yield per acre than the same grains grown separately.

Mixed Barley and Oats Sown in Different Proportions

Having ascertained that a mixture of oats and barley was well adapted to a large production of grain it became of importance to know the best proportions of these grains to use in the mixture to give the most satisfactory returns. For the six years from 1899-1904 mixtures were used varying in amount of seed sown by one-half bushel per acre. For the five years from 1907-1911 the amount of mixtures sown varied only one peck per acre, and in the experiments from 1913-1917, the mixtures varied only one gallon per acre. The leading varieties were used throughout, and the experiment was conducted in duplicate in each of the sixteen years in which this experiment was conducted. There were in all two hundred and eighty-eight plots required for this test. In order to present the results in as concise a form as possible the yields from the different sections of the experiment have been averaged and are condensed into one table. The following report, therefore, gives the average results from this line of investigation which cover in all sixteen separate years:—

Seed sown (Gallons per acre)		Six years 1899-1904		Seed sown (Gallons per acre)		Five years 1907-1911		Seed sown (Gallons per acre)		Five years 1913-1917	
		Yield per acre				Yield per acre				Yield per acre	
		Straw (tons)	Grain (lbs.)			Straw (tons)	Grain (lbs.)			Straw (tons)	Grain (lbs.)
Barley	Oats			Barley	Oats			Barley	Oats		
4	4	2.07	2,240.1	6	6	1.69	2,587.0	7	7	1.81	2,891
8	4	1.96	2,163.5	8	6	1.72	2,597.5	8	7	1.78	2,855
12	4	1.98	2,214.2	10	6	1.68	2,646.9	9	7	1.83	2,939
4	8	2.18	2,265.7	6	8	1.72	2,611.9	7	8	1.95	3,029
8	8	2.04	2,289.9	8	8	1.72	2,658.7	8	8	1.99	3,065
12	8	2.04	2,281.1	10	8	1.70	2,624.8	9	8	2.03	3,048
4	12	2.07	2,216.2	6	10	1.76	2,645.3	7	9	2.02	3,037
8	12	2.02	2,241.1	8	10	1.67	2,580.8	8	9	2.01	3,001
12	12	2.09	2,177.0	10	10	1.66	2,514.3	9	9	1.93	2,946

It will be seen that in each of the three sections of this experiment the highest average yield per acre was obtained from sowing a mixture of one bushel of barley and of one bushel of oats by weight. In other words, when forty-eight pounds of barley and thirty-four pounds of oats, making a total of eighty-two pounds, were sown on one acre of land a greater yield was obtained than that from any one of twenty-four other mixtures made up of different proportions of barley and oats.

Another test is under way in testing different varieties in different proportions, but as this has been conducted for only three years, the results are withheld for further data.

MIXTURE OF OATS AND BARLEY WITH FOUR QUANTITIES OF OTHER GRAIN ADDED

An experiment was conducted in each of the seven years from 1918 to 1924, inclusive, in which a mixture of one bushel of oats and one bushel of barley per acre was used alone and in combination with four different quantities of Wild Goose wheat, Golden Vine peas and common flax. The O.A.C. No. 72 oats and the O.A.C. No. 21 barley were used throughout. The experiment was conducted in duplicate each year. There were, therefore, one hundred and eighty-two plots used in the experiment. The following table gives the summary results of the fourteen separate tests conducted in the seven-year period.

It will be seen that one bushel of barley and one bushel of oats by weight, when grown in combination, produced a higher yield of grain when sown alone than when spring wheat, field peas or common flax were added to the mixture, at the rates of 1, 2, 3, or 4 pecks per acre. These results will undoubtedly be a surprise to some farmers. There seems to be an impression that if Goose wheat, for instance, is added to a standard mixture of oats and barley, the yields of these crops will be maintained and the Goose wheat will be obtained in addition. These results are worthy of considerable study.

Standard mixture	Seed added to standard mixture		Yield of straw (tons)	Yield of grain (lbs.)
	Crops	Quantities		
Barley 1 bush. + Oats 1 bush.	Nothing		2.01	2,877
“ 1 “ + “ 1 “	Spring wheat	1 peck	1.98	2,765
“ 1 “ + “ 1 “	Field peas	1 “	2.04	2,829
“ 1 “ + “ 1 “	Flax	1 “	2.06	2,748
“ 1 “ + “ 1 “	Spring wheat	2 “	2.07	2,753
“ 1 “ + “ 1 “	Field peas	2 “	2.07	2,722
“ 1 “ + “ 1 “	Flax	2 “	1.99	2,700
“ 1 “ + “ 1 “	Spring wheat	3 “	2.04	2,646
“ 1 “ + “ 1 “	Field peas	3 “	2.06	2,825
“ 1 “ + “ 1 “	Flax	3 “	2.01	2,639
“ 1 “ + “ 1 “	Spring wheat	4 “	1.98	2,630
“ 1 “ + “ 1 “	Field peas	4 “	2.04	2,646
“ 1 “ + “ 1 “	Flax	4 “	1.92	2,526

Mixture of Oats and Barley with Other Crops Added

For five years in succession an experiment was conducted to determine whether a mixture of oats and barley could be improved upon by adding a quantity of some other kind of seed. This test was conducted in duplicate each year and the standard mixture used contained one bushel of oats and one and one-half bushels of barley per acre. On one plot of each of the duplicate tests oats and barley alone were sown, and on each of the others half a bushel of some other kind of seed was added to the oats and barley mixture. The following table gives the average results in yield per acre of the two tests for each of the five years:—

Mixtures	Tons of straw	Lbs. of grain
Oats (34 lbs.), Barley (72 lbs.)	2.2	2,612
Oats (34 lbs.), Barley (72 lbs.), Flax (28 lbs.)	2.4	2,566
Oats (34 lbs.), Barley (72 lbs.), Emmer (22 lbs.)	2.2	2,545
Oats (34 lbs.), Barley (72 lbs.), Goose wheat (30 lbs.)	2.2	2,512
Oats (34 lbs.), Barley (72 lbs.), Hulless barley (30 lbs.)	2.2	2,457

The results of this experiment show that when flax, emmer, Goose wheat, or hulless barley is added to a mixture of oats and barley, the yield per acre of the resulting crop was reduced in every instance.

A Co-operative Experiment with Mixed Grain

For nine years from 1918 to 1926, inclusive, a co-operative experiment was conducted throughout Ontario for the purpose of ascertaining whether or not the addition of one-half bushel of Goose wheat per acre or one-half bushel of Golden Vine peas per acre to a mixture of one bushel of oats and one bushel of barley would be of any advantage in producing a larger yield of grain on the farms of Ontario. No reports from successfully conducted experiments were received in 1918, 1924 or 1926. In the average of six years in which thirteen reports of successfully-conducted experiments were received, one bushel of oats and one bushel of barley, by weight, produced 2,047 pounds; one bushel of oats, one bushel of barley and one-half bushel of Golden Vine peas, by weight, produced 1,949 pounds; and one bushel of oats, one bushel of barley and one-half bushel of Goose wheat, by weight, produced 1,834 pounds per acre. These results quite closely parallel those of experiments conducted at the College.

MIXTURE OF BARLEY AND OATS WITH SPRING RYE ADDED

It will be remembered that in a former experiment, spring rye came third in the list in percentage of crop produced from eight kinds of grain grown in combination over a period of twenty years. To glean further information on the use of rye in mixtures, an experiment was conducted in duplicate for five years, by using barley and oats at the rate of one bushel of each in combination per acre alone, and with one peck, two pecks and three pecks of spring rye additional. The following table gives the average results of the ten separate tests conducted in the five-year period:—

Standard mixture	Seed of spring rye added to standard mixture		Yield of straw (tons)	Yield of grain (lbs.)
Barley 1 bush. Oats 1 bush.........	Nothing...........	....	1.69	2,425.6
“ 1 “ “ 1 “	Spring rye.......	1 peck	1.70	2,219.4
“ 1 “ “ 1 “	“	2 “	1.81	2,139.3
“ 1 “ “ 1 “	“	3 “	1.80	2,071.0

It will be seen that the standard mixture of barley and oats when grown alone, gave a greater yield than when rye was added. As the amounts of spring rye added to the mixture increased, there was a gradual decrease in grain production.

COMPARING WEIGHTS, MEASURES AND NUMBERS OF KERNELS IN SEED MIXTURES

Starting in 1922 and extending to 1926, an experiment has been conducted in growing barley alone, and barley in combination with oats, rye and hulless barley according to weights, measures and numbers of seed. Of the twelve different seedings under comparison the highest return was made by the combination of one bushel of barley by weight and one bushel of oats by weight per acre. This combination, however, was followed by the average of all of the results when barley was sown alone at the rate of two bushels by weight per acre. The more this question is studied the more difficult it seems to get a combination which will surpass an ideal combination of barley and oats. It is very easy to secure combinations of barley and other classes of grain which will give a less yield per acre than a mixture of barley and oats, or even from barley when grown by itself.

VARIETIES OF THE SAME CROP GROWN SEPARATELY AND IN MIXTURES

For five years experiments were conducted with each of barley, oats and winter wheat to find out the influence of growing different varieties of the same class of crop, singly and in combination.

In barley there seemed to be some increase in yield by growing two varieties together, providing they were quite distinct in character. In each of the five years Mandscheuri and Black Japan varieties of barley were used in one set, and Two-rowed Canadian and French Chevalier in the other. In the first-named varieties the mixture gave a little higher return than from either grown separately. In the two-rowed varieties, however, the yield from the mixture was between the yields of the two varieties grown separately.

In oats the results of the experiments show no increase in either yield of grain or of straw per acre or in weight per measured bushel from growing varieties in combination in comparison with the average of the same varieties when grown separately.

The results of the experiment also showed no advantage in growing varieties of winter wheat in combination in comparison with the same varieties when grown separately under similar conditions.

Early and Late Oats and Early and Late Barleys Grown in Combination

For five years in succession an experiment was conducted in duplicate each year in testing nineteen combinations of grains of different varieties, taking into consideration particularly the stage of maturity of the different kinds. Two early oats, the Daubeney and Alaska, were used with two late varieties, the Banner and the Siberian. The Mandscheuri barley was used throughout. It was found that the early oats grown in combination with Mandscheuri barley gave an average of 2,417 pounds of grain per acre, and the late oats grown with the same barley gave 2,261 pounds per acre. The Two-rowed Canadian, a late two-rowed barley, was also grown with Banner oats and with Siberian oats, and the average return for the five-year period was 2,148 pounds of grain per acre.

In another experiment conducted for five years, the O.A.C. No. 3 oats and the O.A.C. No. 21 barley were combined in the proportions of three, four and five pecks of each and compared with O.A.C. No. 72 oats and two varieties of late-maturing barley, sown in the same quantities. The averages of the variety combinations show that the O.A.C. No. 3 oats and the O.A.C. No. 21 barley gave 2,560 pounds of grain per acre, and the other combination of O.A.C. No. 72 oats and the other late barley gave 2,074 pounds per acre.

In an experiment conducted for six years in succession, three varieties of early oats were used in combination with six-rowed barley. As the result of the duplicate experiment for the six-year period, it was found that six-rowed barley and Yellow Kherson oats gave twenty-nine pounds per acre more than six-rowed barley and Alaska oats, and ninety pounds per acre more than six-rowed barley and Daubeney oats.

From these, as well as from other results, we have obtained the highest yields by using the best early oats and the best six-rowed barley in combination and we have found it exceedingly difficult to get any combination which will give higher returns than the O.A.C. No. 21 barley and the O.A.C. No. 3 oats.

Hairy Vetches Grown with Three Winter Crops

Hairy vetches have given very good results in Ontario as a forage crop and also as a seed producer. When the vetches are grown alone, however, there is a danger of the crop producing heavily of green fodder, which lies closely on the land and prevents the highest production of seed of first-class quality. An experiment was started with the idea of combining hairy vetches with other crops with the main object of securing a good yield of vetch seed of high quality. Since 1916 this experiment has been conducted in each of five years. Vetches throughout were sown at the rate of one bushel or sixty pounds of seed per acre. Three combinations were made, one with sixty pounds of Dawson's Golden Chaff winter wheat, another with fifty-six pounds of Petkus rye and another with forty pounds of winter emmer. The experiment was conducted in duplicate in each of the five years. The following table gives the average results of the ten tests in the five-year period:—

Seed mixtures per acre	Height (ins.)	Per cent. of crop lodged	Yield of grain per acre (lbs.)	
			Vetches	Other grain
Hairy Vetches, 1 bush. Winter Wheat, 1 bush.....	43	70	344.5	1,083.3
" " 1 " Winter Rye, 1 "	57	46	419.6	2,032.8
" " 1 " Emmer, 1 "	44	69	395.9	*571.7

*Average of four years only.

It will be seen that when one bushel of hairy vetches is sown in combination with one bushel of winter rye, about seven bushels of vetch seed was obtained in addition to fully thirty-six bushels of rye per acre. This combination standing better than either of the others was easiest to harvest when ripe.

A Mixture of Hairy Vetches and Winter Rye grown for grain production.

Hairy Vetches Sown with Winter Rye in Different Proportions

An experiment which was finished in 1923 had been conducted in each of six years in which hairy vetches at the rates of one-half and one bushel per acre, were sown with Petkus rye at the rates of one, two, three and four pecks per acre. The following gives the average results of the six years' experiment:—

Seed mixtures per acre	Per cent. of crop lodged	Yield of grain per acre (lbs.)	
		Hairy Vetches	Petkus Winter Rye
Hairy Vetches, ½ bush. Winter Rye, 1 peck	51	338.5	1,320.4
" ½ " " 2 pecks	49	431.6	1,578.1
" ½ " " 3 "	46	436.2	1,602.3
" ½ " " 4 "	48	431.3	1,796.7
" 1 " " 1 "	64	429.5	1,286.8
" 1 " " 2 "	66	471.8	1,610.7
" 1 " " 3 "	63	456.3	1,687.3
" 1 " " 4 "	58	401.0	1,702.5

Although the highest return of hairy vetch seed was obtained from one bushel of hairy vetch seed and two pecks of rye per acre, it would seem that when the main object is the production of hairy vetch seed of high quality, a seeding of one-half bushel of hairy vetches and one-half bushel of winter rye makes a very good combination for sowing.

Hairy Vetches Sown with Spring Wheat and with Spring Rye

With the special object of obtaining a good yield of hairy vetch seed from spring seeding, the crop was sown at the rate of one bushel per acre along with one bushel of Marquis wheat, and also with one bushel of O.A.C. No. 61 spring rye. The experiment was repeated for five years, finishing in 1922. The following table gives the average annual results:—

Seed mixtures per acre	Yield of grain per acre (lbs.)	
	Vetches	Other grain
Hairy Vetches, 1 bush., Marquis Spring Wheat, 1 bush	156.3	896.7
Hairy Vetches, 1 bush., O.A.C. No. 61 Spring Rye, 1 bush	119.7	1,334.0

When sown in the spring, hairy vetches gave a higher yield of seed when grown with spring wheat than when grown with spring rye.

Hairy Vetches Sown with Spring Rye in Different Proportions

For five years in succession finishing with 1922, hairy vetches were sown with spring rye in different proportions with the object of securing the highest yield of hairy vetch seed of good quality. The following gives the average annual results for the five-year period:—

Seed mixtures per acre	Yield of grain per acre (lbs.)	
	Hairy Vetches	Spring Rye
Hairy Vetches, 45 lbs. O.A.C. No. 61 Spring Rye, 56 lbs.	87.5	1,363.9
" 60 " " " 84 "	108.7	1,416.1
" 75 " " " 112 "	103.3	1,439.9

These results as well as others indicate that the yield of seed of hairy vetches from spring sowing is comparatively light. Winter seeding is usually preferable whether the hairy vetches are sown alone or in combination with some grain which will keep the vetches from lying closely on the ground.

MIXTURES OF GRAIN FOR GREEN FODDER

For six years an experiment was conducted by sowing peas, oats, barley and spring wheat separately and in various combinations to find out which would be the most suitable for producing a large amount of valuable feed to be used either as green fodder or as hay. The experiment was conducted in duplicate throughout. In each of the years the grains were sown separately and in various combinations with two, three or four kinds of grain in each combination. This required fifteen plots in each set or thirty plots in the duplicate experiments so that one hundred and eighty plots were used in this experiment in the six years. The following table gives the average annual results from the grain grown singly, and in the various combinations for the six-year period:—

Crop	Yield of green crop per acre (tons)	
	Grown separately	Grown in mixtures
Oats and Peas	7.41	7.93
Peas and Barley	6.60	7.20
Oats, Peas and Barley	6.72	7.07
Oats and Barley	6.17	6.78
Oats, Peas and Wheat	6.24	6.53
Oats, Peas, Barley and Wheat	6.02	6.56
Oats and Wheat	5.44	6.09
Oats, Barley and Wheat	5.41	6.09
Peas and Wheat	5.88	6.03
Peas, Barley and Wheat	5.93	5.88
Barley and Wheat	4.63	5.04

From an examination of the foregoing table it will be seen that in the average yield of green crop per acre, the grain grown in mixtures gave more than the same grains grown separately in fully ninety per cent. of the experiments. It will also be observed that of all the mixtures used, peas and oats gave the largest yield of green crop per acre. Oats, peas, barley and wheat when grown in various mixtures appear to exert an influence upon the resulting crop in the order named, oats producing the greatest influence and wheat the least. It is very important in selecting varieties of grain to grow in mixtures for the production of either green fodder, hay or grain that varieties be selected which require about the same length of time to reach the proper stage for harvesting when all are sown on the same date.

OATS AND PEAS SOWN IN DIFFERENT QUANTITIES FOR FODDER

An experiment was conducted for seven years in succession by sowing nine different proportions of oats and peas, in order to determine which mixture and which quantity of seed would give the best results in the production of fodder. The experiment was conducted in duplicate in each of the seven years, thus requiring eighteen plots per year, or a total of one hundred and twenty-six plots in the seven years. The following table gives the average annual returns for the seven-year period:—

Mixtures	Height (ins.) 3 years	Per cent. of crop lodged 3 years	Yield of green crop per acre (tons) 7 years
Oats, 2 bush. Peas, 1 bush	41.3	2	9.31
" 2 " " 2 "	41.8	9	9.08
" 2 " " 3 "	41.0	22	9.38
" 1½ " " 1 "	41.3	4	8.77
" 1½ " " 2 "	41.3	13	9.13
" 1½ " " 3 "	41.2	35	9.09
" 1 " " 1 "	40.2	7	8.49
" 1 " " 2 "	40.3	21	8.64
" 1 " " 3 "	40.3	40	9.03

From an examination of the foregoing results it will be seen that two bushels of oats and three bushels of peas gave 9.38, and one bushel of oats and one bushel of peas, 8.49 tons per acre. When everything is taken into consideration, it would seem that the best practical results were obtained from a combination of two bushels of oats and one bushel of peas per acre. This combination stood up the best of all, the yield was second highest and in fact was practically equal to the highest producer which required a much larger quantity of seed per acre. Two bushels of oats and one bushel of peas, making a total of three bushels per acre, produces a crop which not only stands up well and gives a high yield, but also produces green fodder and hay of excellent quality, making a well-balanced feed as the oats are rich in carbohydrates and the peas in albuminoids.

VARIETIES OF OATS AND PEAS FOR MIXED FODDER

An experiment was started in 1923 and has been conducted for four years in growing the O.A.C. No. 72 oats and Golden Vine peas in combination in nine different proportions. The highest average yield in tons of green fodder per acre up to the present time has been obtained from seventy-six pounds of oats and seventy-six pounds of peas per acre. This would be two bushels and eight pounds of oats and one bushel and sixteen pounds of peas per acre. The average annual yield of green crop has been 9.7 tons in comparison with 8.9 tons for the mixture of two bushels of oats and one bushel of Golden Vine peas per acre. This experiment is being continued in the future.

The results of experiments show that for green fodder and for hay a mixture of two bushels of oats such as O.A.C. No. 144, O.A.C. No. 72 or Banner varieties and one bushel of peas such as Multipliers, Golden Vine or Prussian Blue varieties makes an admirable seeding for growing in combination. The O.A.C. No. 144 oats and the Multiplier peas possess characteristics peculiarly suited for the production of a crop which will stand up well and give a very heavy yield of green fodder or of hay. This variety of oats is exceedingly stiff in the straw and this variety of peas has the pods well distributed along the vine rather than bunched at the top as is the case with some varieties. The Mackay variety of peas is somewhat similar to the Multipliers and may also prove serviceable for use in growing with oats for fodder purposes.

SOY BEANS, DENT CORN AND SUNFLOWERS GROWN ALONE AND IN COMBINATION FOR GRAIN AND FODDER

In each of five years finishing with 1925 an experiment was conducted by growing O.A.C. No. 111 Soy beans, White Cap Yellow Dent corn and Black Giant sunflowers alone and in different combinations. The experiment was conducted in duplicate each year. The following gives the average annual results of this experiment for the five-year period:—

Varieties and combinations	Distance between plants	Average height of plants (ins.)	Weight of freshly cut crop (tons)		Yield of grain per acre (lbs.)	
			Singly	Collectively	Singly	Collectively
Soy beans............	½ link	34	8.5	8.5	905	905
Dent Corn............	10 ins.	101	15.5	15.5	2,168	2,168
Sunflowers............	10 ins.	95	17.1	17.1	1,676	1,676
Dent Corn............	10 ins.	100	11.4	14.8	1,241	1,563
Soy Beans............	½ link	36	3.4		322	
Sunflowers............	10 ins.	94	15.4	17.0	1,470	1,651
Soy beans............	½ link	34	1.6		181	
Dent Corn............	10 ins.	71	3.3	17.5	90	1,446
Sunflowers............	10 ins.	95	14.2		1,356	
Dent Corn............	20 ins.	..	3.2	16.0	224	1,570
Sunflowers............	20 ins.	93	12.8		1,346	
Soy Beans............	½ link	34	1.4	18.8	120	1,635
Dent Corn............	10 ins.	73	3.2		130	
Sunflowers............	10 ins.	94	14.2		1,385	

One of the striking features of this experiment is the very low yield of Dent corn when grown in combination with sunflowers. The Dent corn when grown alone gave an average of fifteen and one-half tons per acre and when grown with sunflowers yielded only from 3.2 to 3.3 tons per acre. The highest total yield of green crop per acre, however, was obtained from the Soy beans, Dent corn and sunflowers when grown in combination, the average being 18.8 tons or 1.7 tons per acre more than the sunflowers when grown alone. As one of the most interesting phases of this line of investigation is the value of a combination of Soy beans and Dent corn, we here give the detailed results of the weight of green material when these two crops were grown separately and in combination in each of seven years:—

Crops	1919	1920	1921	1922	1923	1924	1925	Average 7 years
Soy Beans	8.6	8.9	4.6	6.5	10.2	9.4	7.3	7.9
Dent Corn	12.7	13.3	6.0	13.8	18.1	14.5	18.2	13.8
Soy Beans and Dent Corn	13.9	13.3	8.2	12.2	18.4	15.2	15.2	13.8

A Mixture of Dent Corn and Soy Beans for Fodder.

It will be seen that while there are some variations according to season, the average for the seven years gives exactly the same total weight for corn alone as for corn and Soy beans combined. It will be understood of course that the Soy beans being rich in albuminoids will make, when mixed with corn, a much richer and better balanced ration for feeding purposes.

It is also of much interest to compare the results of Dent corn and Soy beans when grown separately and when grown in combination for grain production.

The following table gives results in detail for each of the five years from 1920 to 1925, inclusive:—

Method of growing		Distance between plants	Yield of grain per acre (lbs.)						Ave. yield of seed per acre	
			1920	1921	1922	1923	1924	1925	Each crop	Whole crop
Grown separately	Dent Corn.	10 ins.	2,325	566	3,038	3,238	710	3,129	2,168	2,168
	Soy Beans.	½ link	820	804	957	1,132	716	999	905	905
Grown in combination	Dent Corn.	10 ins.	1,275	429	743	1,719	353	1,925	1,241	1,563
	Soy Beans.	½ link	413	342	205	375	326	271	322	

These results show that in every instance the corn gave a decidedly lower yield of grain per acre when the Soy beans were grown with it as compared with the corn grown alone. A surprising feature is that in only 1921 and in 1924 did the corn and beans combined give as high a yield of grain as the corn when grown alone. We have had but few experiments in which there were such variations in results, and yet the tendency of the experiment would seem to point to the conclusion that it is preferable when everything is taken into consideration for grain production, to grow Dent corn and Soy beans separately rather than in combination. Three acres of corn and two acres of Soy beans would give a greater total production of each crop than if five acres of the two crops were grown in combination. Further experiments along this line should be conducted before definite conclusions can be obtained.

Soy Beans Grown with Millets, Sorghums, etc., for Fodder

In each of the past two years the O.A.C. No. 211 variety of Soy beans has been grown alone and with seven other fodder crops. The experiment was conducted in duplicate each year. The two years' tests show the following average annual yields in tons of green crop per acre when the O.A.C. No. 211 Soy beans were grown with each of the crops here indicated: Early Amber Sugar Cane, 19.9; Japanese Barnyard Millet, 16.1; White Kaffir Corn, 15.8; Japanese Panicle Millet, 14.3; Sudan Grass, 12.7; Hungarian Grass, 11.5; Teff Grass, 11.2. Unfortunately, in 1925 the O.A.C. No. 211 Soy beans were not grown separately sufficiently close to the others to enable the results to be presented. In 1926 the O.A.C. No. 211 Soy beans gave an average weight of 11.08 tons per acre. This experiment will be continued for several years.

Sweet Clover with Millets, Sorghum, etc., for Fodder

In 1926 an experiment was conducted for the first time in which sweet clover was grown alone in comparison with sweet clover with each of seven other crops. The average yield in tons of green crop per acre in 1926 was, for sweet clover when grown alone, 6.3; and when grown in combination with Japanese Barnyard Millet, 15.7; Japanese Panicle Millet, 14.1; Early Amber Sugar Cane, 13.7; Sudan Grass, 13.5; Teff Grass, 12.4; White Kaffir Corn, 11.0; and Hungarian Grass, 9.8. This experiment will be repeated for several years.

VARIETIES OF OATS

According to the Ontario Department of Agriculture, the oat crop of Ontario for the last forty-four years has had an average annual value of $36,385,924. This amount, however, has been considerably increased in recent years, sometimes being more than doubled.

In each of the provinces, with the exception of the three prairie provinces, oats are grown more extensively than all other grain crops combined. As the oat crop is the most generally grown of all the grain crops throughout the Dominion the comparisons of the different provincial yields are of very great interest.

Valuable information has been collected through the Dominion Bureau of Statistics, Ottawa, Ontario, for the twenty years from 1907 to 1926, inclusive, the results of which have been issued through the Monthly Bulletin of Agricultural Statistics which is now in its twentieth volume. Unfortunately, the statistics of British Columbia were not complete for the first three of the twenty years. Based on Dominion data the following table gives the average yield of oats per acre for the ten years from 1907 to 1916 and for the ten years from 1917 to 1926, inclusive. It also shows the average annual increase or decrease in bushels per acre for the latter as compared with the former period for each of the provinces:—

Provinces	10 years 1907-1916	10 years 1917-1926	+Increase −Decrease
Ontario	33.20	36.7	+ 3.50
Nova Scotia	31.51	32.2	+ .69
New Brunswick	28.95	28.7	− .25
Quebec	26.86	26.6	− .26
Prince Edward Island	32.63	32.3	− .33
Manitoba	36.96	32.3	− 3.66
Saskatchewan	38.66	29.2	− 9.46
Alberta	41.61	29.8	−11.81

It is interesting to note from the summary of the Dominion results that the oat crop of Ontario has made an actual increase of 3.5 bushels per acre per annum for the last ten years in comparison with the ten years previous. With the exception of Nova Scotia which made a slight increase, all provinces both east and west of Ontario have shown a decrease in acre yields, the decrease in Alberta being 11.8 bushels per acre per annum. In the average results for the whole twenty-year period Ontario has given the greatest average yield per acre with the exception of Alberta, which surpassed it by an average of three-quarters of a bushel per acre. Undoubtedly one of the great reasons that acre yields of oats in Ontario have increased more rapidly than those of any other province of the Dominion is owing to the fact that the people of Ontario have been growing very largely new varieties originated in Ontario which have given higher returns than those grown formerly in this Province or those which are grown extensively in the other provinces at the present time. If Ontario farmers can be protected from the introduction of lower yielding varieties even though the seed is registered, there seems no reason why the acre yields of oats will not keep on increasing in this Province as the new high-yielding varieties such as O.A.C. No. 144, O.A.C. No. 72 and O.A.C. No. 3 become even more generally used and as other new selections and crosses are introduced from time to time and brought into general cultivation. With these facts in mind a careful study of the following results of experiments with oats should prove of exceptional interest.

About three hundred and fifty varieties of oats have been carefully tested in the experimental grounds at the College. Many of these have been dropped after they have been grown for five years in succession owing to the fact that other varieties, some of which originated by selection or by hybridization, have proven more successful. Each year a few new varieties are added and a few of the inferior ones are dropped.

EIGHT VARIETIES OF OATS UNDER TEST FOR 37 YEARS

Each of eight varieties of oats have been grown under similar conditions in our experimental grounds in each of the thirty-seven years from 1890 until 1926, inclusive. The following table gives the average annual results of each variety for the thirty-seven-year period:—

Varieties	Weight per measured bushel (lbs.)	Yield per acre	
		Straw (tons)	Grain (bushels by weight)
Siberian	33.69	2.23	84.9
Banner	32.93	2.33	82.9
Probsteier	33.63	2.15	82.5
Oderbrucker	32.95	2.25	81.8
Joanette	34.07	2.50	81.3
Bavarian	32.71	2.44	79.3
Egyptian	35.34	2.45	73.5
Black Tartarian	30.76	2.38	69.1

Of all the oats which have been grown at the College for thirty-seven years in succession, the Siberian heads the list in yield of grain per acre. Previous to 1902, each of one hundred and seventy-four named varieties of oats had been tested in our experimental grounds for at least five years and ten of the best ones had been tested under similar conditions for twelve or more years. Of the white oats, the Siberian, which the College imported from Russia, was the most productive in the twelve-years' test, surpassing the Banner in quality of grain and in average yield per acre per annum by 3.9 bushels. The Siberian variety did well at the College and was distributed over Ontario through the medium of the Experimental Union and it was later estimated that it became the second most extensively grown variety of oats in this Province.

The Banner oats, which stand second in the accompanying list, was introduced as Vick's American Banner by Jas. Vick and Sons, Rochester, New York, in 1886. The writer imported the Banner from the introducers in 1890, since which time both the original variety and many strains from various sources have been tested in the experimental grounds. Although the Banner gave considerably better results than some of the older varieties such as the Black Tartarian and the Egyptian, we have always had a few varieties of oats which have surpassed the Banner in productiveness in the tests at the College and in the co-operative experiments throughout Ontario.

VARIETIES OF OATS ELIGIBLE FOR REGISTRATION IN CANADA IN 1924

For over a quarter of a century, the Canadian Seed Growers' Association has conducted excellent work throughout Canada in the production of pure seed of the best varieties of oats and wheat, and for a shorter period with other classes of farm crops. Up to 1924 seven varieties of oats had been selected by the Association as of sufficient merit to be eligible for registration. As these seven varieties have been grown under uniform conditions in our experimental grounds at Guelph in each of the past sixteen years, the results should be of great value not only to Ontario but to the whole Dominion. In no other place have all of these varieties been tested for nearly so long a time. The following table gives the average annual results for the sixteen-year period:—

Variety	Maturity (days)	Height (ins.)	Hull (per cent.)	Yield per acre	
				Straw (tons)	Grain (bushels by weight)
O.A.C. No. 72	110	46.7	28.8	2.15	84.6
O.A.C. No. 3	99	40.3	24.8	1.88	83.4
Abundance	107	42.8	28.8	2.01	79.8
Gold Rain	109	42.0	30.0	1.89	79.7
Victory	109	41.7	30.0	1.84	78.1
Banner	110	43.9	30.2	2.11	77.0
Alaska	101	41.4	23.9	1.70	74.6

As the Siberian variety of oats, which had been imported by the College from Russia, had given better results in twelve years' experiments than the Banner, which had been imported by the College from the United States, the former was used for selection work. In 1903 nearly 10,000 seeds of the Siberian variety were planted by hand at equal distances apart. From one of the several selected plants from this extensive nursery the O.A.C. No. 72 variety of oats was started. The O.A.C. No. 72 variety of oats is a late, vigorous grower and has fairly stiff straw, spreading head, white grain and gives a high yield of grain of good quality.

This new variety of oats has made a wonderful record, not only in the experiments at the College as indicated in the results here presented but it has also been a leader in the co-operative experiments throughout this Province and in the Standing Field Crop Competitions carried on by the Agricultural Societies of Ontario. It has been increased so rapidly that for a number of years past it has been one of the two most extensively grown varieties of oats in this Province and has had a marked influence in increasing acre yields throughout the country.

In the Ontario Field Crop Competitions judges carefully examined the fields of oats immediately before they were harvested, taking into consideration yield and quality of grain, absence of lodging, vigor of growth, uniformity of maturity and freedom from diseases, insect injury, weeds, and other grains. Of the 1,108 first prizes awarded by these men in an eight-year period, O.A.C. No. 72 received 565, Banner 307, Abundance 21, Gold Rain 13, and all other varieties combined 202.

The O.A.C. No. 3 variety of oats was started at the College from a single seed in 1902. It originated from the early, thin hulled, good yielding Daubeney oat which possessed some variations. The new oat has been a decided improvement over the old Daubeney variety. It is now grown in Ontario alone and also in combination with O.A.C. No. 21 barley, for which it is admirably adapted. This is an important factor in itself as in 1926 there were 770,981 acres of grain grown in combination in Ontario.

The O.A.C. No. 3 is very early and possesses good straw, a spreading head, white grain which is practically free from awn and is very thin in the hull and gives a high yield per acre. This new variety of oats has filled a very important place in oat production in Ontario. The grains lack somewhat in attractiveness as they are fairly long and not very large, but when farmers realize that they have a lower percentage of hull than nearly all other varieties grown in the Province, they appreciate the very high quality of the feeding value of the O.A.C. No. 3. This high quality combined with the early characteristics of maturity make a unique combination.

The Ontario Agricultural College imported the Abundance oats from France in 1889, from Ireland in 1902, and from England in 1911; the Victory from Sweden in 1911 and the Alaska from the United States in 1900. The Gold Rain was imported from Sweden in 1911 by L. H. Newman, then Secretary of the Canadian Seed Growers' Association and now Dominion Cerealist, and the College received some of this seed from him in that year. The Banner was described under the former heading.

VARIETIES OF OATS ELIGIBLE FOR REGISTRATION IN CANADA IN 1926

In the two years, 1925 and 1926, only one additional variety of oats was accepted for registration in Canada. At the annual meeting of the Canadian Seed Growers' Association held at Edmonton, Alberta, in June, 1925, the O.A.C. No. 144 variety of oats was accepted as a variety of sufficiently high merit to be eligible for registration throughout the Dominion. This variety was originated at Guelph, and in addition to numerous preliminary tests was entered into the regular experimental work with varieties of oats nine years ago. The following table gives the average results of each of the eight varieties of oats now eligible for registration in Canada and which have been under uniform test at the Ontario Agricultural College for the past nine years:—

Varieties	Weight of 1,000 kernels (grammes)	Maturity (days)	Height (ins.)	Hull (per cent.)	Yield per acre	
					Straw (tons)	Grain (bushels by weight)
O.A.C. No. 144	35.8	111	47.4	29.7	2.52	89.6
O.A.C. No. 3...	32.2	100	38.3	25.5	1.88	86.5
O.A.C. No. 72..	38.5	111	45.5	29.2	2.12	82.7
Gold Rain.....	35.3	108	42.1	29.7	1.95	82.7
Abundance....	40.3	109	42.7	29.1	2.03	80.8
Banner........	41.9	111	43.9	29.8	2.11	78.2
Victory.......	40.1	109	41.9	29.4	1.87	77.5
Alaska........	38.8	100	40.4	23.9	1.65	68.4

The O.A.C. No. 144 variety of oats was started from a selection taken in 1912 from amongst plants of the O.A.C. No. 72 variety. It is decidedly different, however, from the latter and seems distinct from any other of three hundred or more named varieties of oats which have been tested for five years and upwards at the Ontario Agricultural College.

The O.A.C. No. 144 is a tall, vigorous, broad-leaved, exceptionally stiff-strawed, late variety of oats which possesses a spreading head and a long, slightly brownish white grain practically free from awn and which produces a heavy yield of both grain and straw of good quality. The ripening crop has a beautiful appearance with a golden tinge.

The two outstanding characteristics of the O.A.C. No. 144 variety of oats are its high yielding capacity and its great strength of straw. When placed under the severest tests it has frequently stood up very well when Banner, O.A.C. No. 72 and other prominent varieties were partly or completely lodged.

Its great power of standing under adverse conditions has shown itself not only in experiments and in general cultivation throughout Ontario but also when grown at other places under quite different conditions. As an example, I here quote from a letter written on February 5th, 1927, by Major H. G. L. Strange, Fenn, Alberta, who is now President of the Canadian Seed Growers' Association: "I had an awful set-back with my oats this year. I had ninety-five acres of first generation Victory oats that averaged easily one hundred bushels to the acre. I had sold the whole lot to a seed house at $2.00 per bushel and just at harvest time tremendous storms of rain and wind came along and practically the whole lot is still lying flat under the snow. . . . . Your 144 hardly went down at all and I estimate was at least ninety per cent. harvested."

Part of a thirty acre field of O.A.C. No. 144 oats on the College Farm.

For the past four years the O.A.C. No. 144 has made an outstanding record throughout Ontario in connection with the co-operative experiments where it has been successfully tested with other leading varieties on more than three hundred farms located in different localities in nearly every county and district in the Province. These co-operative tests were conducted on a great variety of soils. The average results of more than the three hundred co-operative tests show that the O.A.C. No. 144 gave 133 pounds or practically four bushels per acre per annum more than the next highest yielding variety.

The O.A.C. No. 144 oats do best when sown just as early in the spring as the land can be worked to good advantage. One farmer living near Guelph moved to his new farm in the spring of 1926 and sowed O.A.C. No. 144 oats in the latter part of May and early June and as a result the straw rusted and the oats were light. We have confidence that the O.A.C. No. 144 variety of oats will be a great addition to oat production in Ontario and may also become valuable in other places.

TWENTY-SEVEN VARIETIES OF OATS FOR FIVE YEARS

In each of the last five years twenty-seven varieties of oats have been grown under similar conditions in our experimental plots. Some of these varieties have been grown for many years and other newer kinds have been added from time to time. The list further furnishes some of the most interesting oat material collected or originated within the last forty years. Although the results from five years' tests are not as valuable as those for a much longer time, it is necessary to present the results for a comparatively few years in order to include some of the varieties which have been grown for a comparatively short time. The following table gives the average results for the five-year period for each of these twenty-seven varieties of oats:—

Varieties	Weight of 1,000 kernels (grammes)	Number of days to mature	Height (ins.)	Percentage of Hull	Yield per acre	
					Straw (tons)	Grain (bus. by weight)
O.A.C. No. 144	36.36	112	47	29.7	2.58	97.78
Minota	30.59	109	36	27.8	1.66	95.73
Iowar	29.03	103	37	24.7	1.86	93.42
O.A.C. No. 72	38.91	112	46	29.1	2.15	90.75
Iowa No. 103	27.93	100	36	25.5	1.74	90.17
Yellow Sixty-Day	24.96	103	42	28.6	1.96	89.09
Burt	43.86	99	38	26.0	1.73	86.93
Victory	40.24	110	42	28.9	1.98	84.70
Siberian	41.41	110	40	30.6	1.90	83.46
O.A.C. No. 3	32.15	100	38	25.1	1.80	83.45
Abundance	40.57	109	42	29.1	1.99	82.46
Banner	42.83	112	44	29.6	2.10	82.28
Oderbrucker	43.38	110	44	30.5	2.07	81.85
Regenerated Banner	39.59	110	41	29.6	1.85	79.59
Ligowa	40.73	110	42	29.5	1.96	79.28
Early Ripe	42.46	101	38	24.8	1.92	79.02
Probsteier	41.75	109	41	29.8	1.85	78.48
Joanette	40.65	105	37	24.1	2.13	78.24
Black Tartarian	38.24	111	42	30.0	2.22	76.72
130 Year	30.40	111	41	33.0	1.96	76.10
Bavarian	43.96	109	41	28.3	1.95	73.34
Egyptian	42.11	108	44	33.7	1.92	71.23
Pioneer	34.72	108	39	38.2	2.15	69.89
Daubeney	43.67	101	38	25.1	1.85	69.05
Tartar King	44.74	109	46	33.0	2.14	68.58
Early Dawson	35.34	105	44	36.4	1.98	62.15
Alaska	38.54	100	40	23.7	1.58	54.26

The O.A.C. No. 144 variety of oats, which stands at the head of the list in grain production of all the varieties grown at the College under uniform conditions for the past five years, has already been described under the previous table.

The Minota oat was imported from the State of Minnesota. It is a white oat with a spreading head and was the result of one of several plant selections made in 1906 from a commercial variety of oats grown on the farm of James

A. Bull. In 1915 the Minota oat was first placed in variety trials at the Agricultural Experiment Station and showed its adaptability as a good yielder for Minnesota conditions. This oat is briefly described in Bulletin 226 of the Agricultural Experiment Station, St. Paul, Minnesota.

The Iowar variety of oats was imported from the State of Iowa and was developed at the Experiment Station at Ames, from a single plant of Kherson selected in 1911. It was increased and compared in variety tests at the Experiment Station until 1919 when it was first distributed over the State. The grain is white, medium in size and noticeably awned. Information regarding this oat can be obtained from Bulletin No. 227, Agricultural Experiment Station, Ames, Iowa.

The O.A.C. No. 72 variety was originated in Guelph through a nursery plot selection and was described under the third table previously inserted.

The Iowa No. 103 is a pure line selection made from the Yellow Kherson variety in 1906 at the Iowa Agricultural College. It is an early oat with a white grain and was much more popular than the Yellow Kherson which was discounted on the market owing to its colour.

The Yellow Sixty Day and the Yellow Kherson were tested at Guelph for a number of years and proved to be very similar in characteristics and in yields. As the Yellow Sixty Day gave slightly higher yields than the Yellow Kherson, the latter variety was dropped.

The Burt variety of oats which stands seventh in the list for yield per acre for the last five years is very early, and seems to be entirely immune to smut.

New Varieties of Oats Tested less than Five Years

No less than thirty varieties of oats have been under test at the College for less than five years. Of this number, eight were grown for four years and thirteen were entered into the experiment in 1926 for the first time. In the thirty varieties which have been tested for less than five years are included six varieties obtained through pure line selections at Cornell University and other strains and varieties from Macdonald College, Quebec; Central Experimental Farm, Ottawa; Kansas, Iowa, Saskatchewan, Alberta and numerous other places. In these preliminary tests none of the new varieties have as yet given as high yields or possess straw which stands up as satisfactorily as the O.A.C. No. 144 variety.

Special Test with Special Varieties of Oats

In each of the past eight years five varieties of oats have been grown at the rates of one and one-half, two, and two and one-half bushels of seed per acre. In some of the years, experiments were conducted on both high and low land. In a test of this kind an excellent opportunity is given for testing out special varieties under different seasons and under different conditions so that the average results would be very representative and would cover many separate trials. The following table gives the average results of each variety grown from three quantities of seed per acre and under different conditions of soil.

Varieties	Hull (per cent.)	Weight per measured bushel (lbs.)	Yield per acre	
			Straw (tons)	Grain (bushels by weight)
O.A.C. No. 144	29.9	30.94	2.40	79.27
O.A.C. No. 3	26.0	32.59	1.69	74.86
O.A.C. No. 72	29.7	31.33	2.06	74.19
Banner	30.7	32.30	2.19	72.61
Alaska (O.A.C. No. 157)	24.1	35.35	1.69	72.45

The O.A.C. No. 144 variety again heads the list in productiveness when compared with other varieties under various conditions of weather, soil and seeding.

The following table gives results for the eight-year experiment showing the comparisons of the varieties when sown at different quantities per acre:—

Varieties	Per cent. lodged			Yield of grain		
	Seed used per acre (Bushels by weight)			Seed used per acre (Bushels by weight)		
	1½	2	2½	1½	2	2½
O.A.C. No. 144	23	13	12	79.84	79.05	78.92
O.A.C. No. 3	31	27	30	76.89	78.39	69.31
O.A.C. No. 72	33	34	28	75.52	74.39	72.67
Banner	36	39	35	70.88	74.41	72.55
Alaska (O.A.C. No. 157)	26	23	23	73.85	74.39	69.10

It will be seen that the O.A.C. No. 144 was decidedly stiffer in the straw than the other varieties and gave a higher yield per acre at each of the three rates of seeding.

NEW O.A.C. CROSS-BRED VARIETIES OF OATS

In addition to the O.A.C. No. 144, O.A.C. No. 72 and O.A.C. No. 3, varieties of oats, the College has quite a large number of new selections and cross-bred varieties which may also prove valuable. Of this number it is necessary to refer at this time to only a few of the most promising. For instance, in the last five years' experiments six new cross-bred varieties have surpassed the Banner by from three to ten bushels per acre per annum. These constitute crosses between Joanette and Siberian; Early Ripe and Banner. The highest yielder of these is a cross between the Joanette and the Siberian and has given an average of 92.89 bushels per acre, a weight per measured bushel of 38.55 pounds and a yield of straw per acre of 1.95 tons. It is very short and very stiff in the straw. We are still working with this cross and have not as yet sent to any one any of the seed owing to the fact that it is not entirely constant in all characters and we do not wish to introduce too many varieties at one time. This new variety has not yet quite equalled, on the average, the yield per acre of the O.A.C. No. 144, which is its closest rival in productiveness but is an oat of a very different type.

Some selections have also been made of varieties which we have had under test for many years. For instance in 1911 a large number of selections were made of the Alaska variety of oats. Fifty-one of the best of these were placed in row plots in 1912 and the results were compared in a preliminary way for three years. In 1915 seven of these were entered into the regular variety plot experiments. These were finally cut down to two selections, namely, Alaska (O.A.C. No. 157) and Alaska (O.A.C. No. 201). Of these two the Alaska (O.A.C. No. 157) has given the highest results. The following table gives the comparative returns in annual results of the Alaska and the O.A.C. No. 3 for the last nine years:—

Varieties	Per cent. Hull	Yield per acre	
		Straw (tons)	Grain (bushels by weight)
O.A.C. No. 3	25.5	1.88	86.5
Alaska (O.A.C. No. 157)	23.7	1.81	82.7
Alaska	24.0	1.55	68.4

It will be seen that through extensive selection work a strain of Alaska has been obtained which is considerably superior to the original, but still gives an annual yield of about four bushels per acre less than the O.A.C. No. 3, which was originally selected through nursery plot work from the Daubeney. The Alaska selection is also slightly thinner in the hull than the Alaska variety. The Alaska oat was originally imported by this College from the United States twenty-seven years ago.

Weight of Oats per Measured Bushel

In past years too much stress has been placed on the weight per measured bushel of oats and too little attention given to the quality of the oats as determined by the percentage of hull. The writer has frequently made the statement in the classroom and at meetings of practical farmers that as the result of careful investigation it has been found that as a general rule those varieties of oats which weigh the most per measured bushel are thick in the hull and are light yielders. There are many illustrations to prove this statement. It has been found that weight per measured bushel is influenced more by the length than by the quality of the oat grains of different varieties. A long thin hulled oat of high quality will invariably weigh less per measured bushel than a short plump, thick-hulled variety which is of considerably less value for feeding purposes. It is time the old "yard stick" of weight per measured bushel was entirely discarded as a means of determining the relative value of oats of different varieties. Dr. H. H. Love, Professor of Plant Breeding at Cornell University, in Bulletin No. 334, makes the following statement regarding weight per measured bushel of oats: "As the kernels become longer the weight per bushel becomes less. The varieties having a long kernel in general have a smaller weight per bushel than those having shorter kernels." As the percentage of hull in different varieties of oats varies from about twenty to forty and forty-five per cent. and as the oat hulls are very difficult to digest and contain but little nutritive material this is an exceedingly important question. For instance, as the oat hull of the O.A.C. No. 3 is over five per cent. less than that of the Banner this difference in hull percentage, if applied to the total value of the oat crop of Ontario would mean about $2,000,000 annually in favour of the O.A.C. No. 3 variety as compared with the Banner. The Alaska although a lighter yielder than the

O.A.C. No. 3 is even a little thinner in the hull than the latter variety. The weight per measured bushel of oats especially of some varieties can be reduced considerably by artificial treatment such as clipping or pounding the grain. At the present time more attention is given to the quality of oats than formerly, when the determining factor was largely weight per measured bushel for the different varieties.

Records have been kept annually of the percentage of hull of all of the varieties of oats tested in our experimental grounds. The following table gives the percentage of hull of each of a half-a-dozen varieties in each of the past twenty years:—

Years	Percentage of hull					
	O.A.C. No. 3	Daubeney	O.A.C. No. 72	Banner	Early Dawson	Pioneer
1907	24.7	24.7	27.2	28.3	33.7	38.8
1908	23.6	23.8	25.4	28.6	36.6	37.4
1909	24.8	25.4	28.7	29.6	36.8	36.7
1910	24.4	24.9	28.6	29.6	31.4	33.5
1911	25.0	26.2	27.8	31.3	34.1	36.8
1912	23.8	24.6	28.0	35.5	35.8	37.0
1913	23.0	24.5	25.6	29.2	33.1	35.3
1914	24.3	25.9	28.9	30.7	34.4	36.7
1915	21.7	23.7	28.4	29.1	31.7	35.1
1916	27.2	26.1	32.9	32.0	39.9	40.2
1917	22.7	23.8	26.1	27.2	35.2	34.7
1918	23.0	25.2	27.8	28.5	34.5	35.6
1919	24.0	25.0	30.1	30.4	34.7	36.6
1920	22.5	24.0	27.0	29.0	37.2	36.8
1921	27.2	27.0	30.9	30.8	42.1	39.8
1922	24.3	26.2	32.3	31.6	41.2	43.4
1923	21.8	23.9	28.5	29.9	33.8	36.7
1924	24.1	24.6	28.8	28.5	35.4	35.8
1925	25.9	25.3	28.2	28.8	35.0	36.5
1926	25.4	25.7	27.9	29.3	36.6	38.8
Average 20 years	24.2	25.0	28.5	29.9	35.7	37.1

The percentage of hull in oats varies considerably in the different years. It is interesting to note, however, that the relative proportion of hull of the different varieties is very similar for the different seasons of the whole twenty-year period with only occasional and minor exceptions. It will be observed that the average percentage of hull for the twenty years is only 24.2 for the O.A.C. No. 3, while under exactly similar conditions it is 37.1 for the Pioneer, a difference of practically 13 per cent.

THE STOOLING CHARACTER IN OATS

Varieties	Number of stools per plant												
	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	Ave.
Joanette	21	18	15	26	16	16	19	9	15	13	10	19	16.4
Early Ripe	19	13	16	19	16	19	21	10	16	12	12	20	16.1
Burt	22	13	17	19	18	17	20	9	15	11	10	19	15.8
Yellow Kherson	19	13	15	18	15	13	18	9	14	12	9	19	14.5
Daubeney	18	11	14	14	12	9	15	9	12	10	9	17	12.5
Sixty-Day Yellow	17	12	13	14	10	10	13	8	9	10	8	14	11.5
American Banner	17	10	13	14	10	11	13	9	9	9	8	13	11.3
Siberian	14	12	11	12	9	11	13	9	10	8	8	14	10.9
Regenerated Abundance	11	10	11	14	10	11	13	8	9	8	8	12	10.4
Storm King	8	6	6	9	6	6	8	5	5	5	5	8	6.4
Tartar King	8	5	6	8	6	6	6	5	4	4	5	7	5.8
Average eleven varieties	15.8	11.2	12.5	15.2	11.7	11.8	14.5	8.2	10.7	9.3	8.4	14.8	12.0

The stooling of grains is influenced by the variety, the fertility of the soil, the conditions of the weather, the thickness of seeding, etc. The varieties used, the fertility of the soil and the thickness of the sowing are largely under the control of the farmer. The foregoing table gives the average number of stools per plant of eleven varieties of oats which were planted in squares one foot apart in each direction in each of twelve years.

These results show clearly the variation in stooling influenced by variety and also by season.

The Joanette is a heavy, the Banner a medium and the Tartar King a light stooler.

In the last two years, the stooling character of each of forty-six varieties of oats has been determined. In the average for the two years a new oat under the name of Kanota had 21.5 stools and the Tartar King 6.6 stools. These were the extreme varieties. In the same period the O.A.C. No. 144 had 9.1; the O.A.C. No. 72, 9.2; the Banner, 10.7; the Alaska, 12.1, and the O.A.C. No. 3, 16.1.

It will be seen that the average number of stools per plant per year was 12. In the variation, for the different seasons, however, it will be noticed that in 1916 the average stools per plant of the nine varieties was 8.2, while in 1909 it was 15.8 for exactly the same varieties which were grown in the same experimental grounds where the soil shows no very great variations.

WIDTH OF LEAVES OF SPECIAL VARIETIES OF OATS

The width of leaves of some of the newer varieties of oats showed characteristics which started a comparative study of some of the varieties. It was decided to measure, in every instance, the second leaf from the head. In each of the two years, 1925 and 1926, fifty leaves from fifty separate plants were carefully measured each season. The test included fourteen selected varieties. The following gives the average width in one-hundredth parts of an inch of these varieties starting with the narrowest and finishing with the broadest leaves: O.A.C. No. 3, 45; Alaska, 48; Cole, 51; Regenerated Banner, 66; Abundance, 67; Vick's American Banner, 68; Banner 44 M.C., 68; Alberta Banner, 68; Banner Ottawa 49, 69; Victory, 69; Gerlach, 69; Gold Rain, 70; O.A.C. No. 72, 72; O.A.C. No. 144, 85.

The O.A.C. No. 144 is the broadest leaved variety of oats which we have under experiment and we believe it is the broadest leaved of any of upwards of three hundred varieties which have been grown under experiment at the College in the last forty years. It will be noticed that the width of the leaf of the O.A.C. No. 3 is only about one-half of that of the O.A.C. No. 144. This line of investigation will be followed up for several years.

THE PRESENCE AND ABSENCE OF AWNS ON OATS

The awn of the oat plant is an interesting character. In recent years determinations have been made at our College of the percentage of awned spikelets in the panicle of oats of different varieties. The percentage of awn varies greatly with the variety of oats and it also varies somewhat with season. In some years the awn is rather more prominent than in others. In this respect, therefore, the awn character is much the same as the yield per acre, the weight per measured bushel and other characteristics which vary somewhat from one season to another. The awn character has been claimed by those who have made a careful study in the classification of oats to be a sufficiently constant character to assist in the identification of varieties. In this connection I here refer to two authorities.

Memoir 10, entitled "A Classification of the Varieties of Cultivated Oats," written by Etheridge of Cornell University and issued in 1916, states as follows: "In respect to the actual presence or absence of awns, together with their form, the varieties under study have by observation remained constant."

Bulletin Series C. No. 2 entitled "Varieties of Oats in Cultivation," written by Marquand of the Welsh Plant Breeding Station and issued in 1922, states as follows: "The author has found that the percentage of awned spikelets in the panicle of plants taken from unselected varieties is on the whole constant."

In a six-years' experiment with Banner oats secured from three prominent Ontario members of the Canadian Seed Growers' Association, we obtained at Guelph, the following carefully estimated averages in the percentages of spikelets possessing awn:—

Dixon, Varney, Ont.	3
Brownlee, North Gower, Ont.	54
Bingham, Hillsburg, Ont.	83

The influences of the selections of the old Banner oat by these practical growers as indicated by the results are interesting.

In order to illustrate the awn character in oats the estimated averages in the percentages of spikelets possessing awn in each of twenty-five heads of each of five varieties as determined in 1926 are here given:—

Heads	Per cent. of awned spikelets in each head				
	Kherson	Cole	Banner M.C. 44	Bavarian	Joanette
1	0	0	15	100	100
2	0	0	90	100	100
3	0	0	50	100	100
4	0	0	80	100	100
5	0	0	0	100	100
6	0	0	75	100	100
7	0	0	65	100	100
8	0	0	70	100	100
9	0	0	0	100	100
10	0	0	65	100	100
11	0	0	40	100	100
12	0	0	65	100	100
13	0	0	50	100	100
14	0	0	20	100	100
15	0	0	30	100	100
16	0	0	65	100	100
17	0	0	80	100	100
18	0	0	50	100	100
19	0	0	0	100	100
20	0	0	10	100	100
21	0	0	0	100	100
22	0	0	100	100	100
23	0	0	5	100	100
24	0	0	65	100	100
25	0	0	80	100	100

It will be seen that the Kherson strain used and the Cole variety were absolutely free from awn while Bavarian and Joanette were completely awned varieties. The Banner, however, varied from nothing to one hundred per cent. This Banner and the three Banners previously referred to, varying in percentage of awned spikelets from 3 to 83, have all been registered as Banner by the Canadian

Seed Growers' Association. In 1925 the writer recommended to the Chairman of the Cereal Committee the careful consideration of the registration of Banner oats as this variety has many variations not only in percentage of awn but in shape of grain and in other characteristics.

VARIETIES OF HULLESS OATS

A number of varieties of hulless oats have been secured in Ontario, from Western Canada, from the United States and from China and some selection work with one of the varieties was carried on at our College. The Liberty Hulless originated through cross-fertilization by Dr. Chas. E. Saunders, Central Experimental Farm, Ottawa, has surpassed in productiveness all other varieties of hulless oats. It is an early ripening oat with fairly long straw and produces a good yield of grain which is separated from the hull in threshing. This cross-bred variety was introduced in 1918. It was soon secured by our College and has been grown in our experimental grounds for the eight years from 1919 to 1926, inclusive. It has also been used in our co-operative experiments throughout Ontario in each of the past four years, where it has made a good record. This oat will likely be grown considerably in small quantities to use for oatmeal for human consumption and for grinding to produce feed for young pigs and young chickens.

ONTARIO'S BARLEY CROP

According to all the information available it seems very evident that under Ontario conditions the acre value of barley is greater than that of oats. Barley produces a high yield of grain which contains a comparatively large amount of digestible food constituents.

No less than 1,314,135 acres were used for barley and for mixed grains in 1927. The mixed grains, in practically all instances, would be composed of barley and some other crop such as oats or possibly oats and goose wheat and in some instances peas would be included. The barley crop, therefore, occupies an important place in Ontario's crop production.

FIVE VARIETIES OF BARLEY TESTED FOR 37 YEARS

Three six-rowed barleys, one two-rowed variety and one hulless variety have been tested in our experimental plots in each of the past thirty-seven years. The following gives the average results in yield of grain per acre per annum for the whole thirty-seven-year period:—

Class of Barley	Varieties	Yield of grain per acre (bushels by weight)
Six-rowed	Mandscheuri	64.3
	Oderbrucker	59.0
	Common Six-rowed	54.1
Two-rowed	French Chevalier	54.6
Hulless	Black Hulless	43.1

The Mandscheuri has given an annual average yield of fully ten bushels per acre over the common six-rowed which was the variety grown in Ontario extensively when the College imported the Mandscheuri from Russia in the spring of

1889. As this variety was received from Russia under the spelling here indicated this special spelling has been retained throughout, to distinguish it from other somewhat similar but lighter yielding strains, such as Mensury.

It is also interesting to note that the Mandscheuri barley surpassed the French Chevalier by nearly ten bushels per acre per annum. The French Chevalier was imported from France and was considered one of the best yielding two-rowed barleys.

Although the Black Hulless gave an average of only forty-three bushels per acre, it must be remembered that this variety possesses no hull, while the other varieties have usually from twelve to eighteen per cent. of hull.

SEVEN VARIETIES OF SIX-ROWED BARLEY TESTED FOR 20 YEARS

The barley grown in Ontario is almost entirely of the six-rowed type. The two-rowed barleys have been tested in this province on different occasions both in a small and a large way, but have never been able to replace the six-rowed varieties except to a very limited extent.

The following table gives the average results of each of seven varieties of six-rowed barley which have been under test for the last twenty years, from 1907 to 1926, inclusive:—

Varieties	Weight of grain per measured bushel (lbs.)	Yield per Acre	
		Straw (tons)	Grain (bushels by weight)
O.A.C. No. 21	48.98	1.66	58.63
Mandscheuri	49.30	1.67	58.49
California Brewing	46.89	1.52	57.52
Oderbrucker	49.70	1.62	54.68
Oregon	45.89	1.57	48.73
Common Six-rowed	50.72	1.55	47.42
*Success	46.93	1.26	44.66

*Results for nineteen instead of twenty years.

Previous to 1903, the Mandscheuri barley which the College imported from Russia had given exceptionally good results in the experiments at the College. In fact, it had made such a high record in comparison with about eighty other varieties which had been included in the tests for several years that it was distributed throughout Ontario in connection with the co-operative experiments. It also made an excellent record throughout Ontario, and in time became the most extensively grown variety of barley in the province. As this variety was outstanding in its performance, it was used as the foundation for work in plant selection.

In the spring of 1903, about ten thousand grains of the Mandscheuri barley were planted separately at equal distances apart in a large nursery plot. This gave the separate plants an opportunity for development under uniform conditions. When the grain was ripe the plants were all carefully examined, and those presenting the most desirable characteristics were harvested separately and carefully stored. The selected plants were afterwards given a more critical examination in the plant-breeding laboratory, and thirty-three of these possessing the largest amount of the best seed were retained for future work. In the spring of 1904, a certain number of seeds from each of the thirty-three plants were planted by hand in separate rows, which furnished an opportunity for a study of the characteristics of the progeny of the individual plants. A critical study was made of these different strains and only the best were continued in the test. From seed obtained in the row plots, regular plots were sown and the crops were compared with other selections, hybrids and varieties. As the result of this careful investigation it was found that what is now called the O.A.C. No. 21 seemed to possess the greatest combination of the most desirable characteristics. The two outstanding characteristics of this variety are its strength of straw and large yielding capacity. Two other strains also made good showings, in fact, surpassed slightly in yield per acre the O.A.C. No. 21, but the last-named variety possessed such excellent straw that it was decided that it would be the most valuable variety from the farmer's standpoint. It was, therefore, increased in quantity, and distributed throughout Ontario through the medium of the Ontario Agricultural and Experimental Union. As the result of the small local test on individual farms throughout the province, the O.A.C. No. 21 barley increased rapidly and it is now estimated that about ninety-eight per cent. of the barley of Ontario is of this variety. This variety has also extended to other provinces and is now estimated that it is the most extensively-grown barley in Canada. As the other two strains have been continued to the present time, the average results of these three strains in comparison with the Mandscheuri from which it was selected are here presented for the twenty-year period:—

Barley	Yield per Acre	
	Straw (tons)	Grain (bushels by weight)
Mandscheuri No. 620	1.69	59.52
Mandscheuri No. 726	1.68	58.86
O.A.C. No. 21	1.66	58.63
Mandscheuri	1.67	58.49

A distinguishing characteristic of the O.A.C. No. 21 is the bluish colour of the kernel underneath the hull of all of the grains. This is one of the important distinguishing characteristics of the O.A.C. No. 21 variety. The other two strains of Mandscheuri here reported have never been introduced into general cultivation, as the O.A.C. No. 21 was preferred as the most important.

The California Brewing, which comes third in the list in the twenty years' results, is a coarse, thick-hulled, short-strawed barley, which we cannot recommend for Ontario.

The Oregon is similar in type and appearance to a variety obtained more recently under the name of Bark, which is grown to some extent in Alberta.

The Success is not a bearded barley, but is what is known as a hooded variety. At the time of its introduction it was extensively advertised, but its cultivation in Ontario has been exceedingly limited and, in fact, the variety has almost disappeared.

SIX-ROWED AND TWO-ROWED BARLEYS TESTED FOR 10 YEARS

In 1926, a special table was prepared of our results of varieties of barley for the past ten years, at the request of the Department of Agriculture, Washington, D.C. The results here presented were summarized for that purpose. The following table, therefore, gives the average results for the ten-year period:—

Varieties of Barley	Six-rowed or Two-rowed	Yield per Acre (bushels by weight)
Binder	Two-rowed	55.61
O.A.C. No. 21	Six-rowed	55.48
California Brewing	Six-rowed	54.36
French Chevalier	Two-rowed	53.79
Mandscheuri	Six-rowed	53.48
Gold	Two-rowed	52.21
Oderbrucker	Six-rowed	51.63
Oregon	Six-rowed	46.25
Common Six-rowed	Six-rowed	43.46
Duckbill	Two-rowed	37.86

As the French Chevalier barley has been grown in our experiments for such a long time it forms a good basis for comparison. It will be observed that the Binder has given 1.8 bushels per acre more than the French Chevalier. The two-rowed barleys are very subject to climatic conditions. In some years they yield heavily in Ontario, and in other years poorly. There is a great danger of people becoming misled by short-term results of the two-rowed barley, basing their conclusions entirely on a comparatively short time. Even in as long a time as ten years, however, the two-rowed has done better, comparatively speaking, than for a longer period. It will be observed that the French Chevalier slightly surpassed the Mandscheuri in ten years, while in twenty-seven years the Mandscheuri gave a yield considerably higher than the French Chevalier.

The Binder barley, or Abed Binder, as it is also called, was produced at the Experiment Station at Abed, Denmark, "being a pure line out of an old Danish variety." Seed of this variety was not imported directly by the College, but was obtained from L. H. Newman, then secretary of the Canadian Seed Growers' Association, also from J. A. Clark, Prince Edward Island, and from the Bureau of Plant Industry, Washington, D.C. It is the most promising of the two-rowed barleys which have been tested at the College.

O.A.C. BRED AND OTHER NEW VARIETIES OF BARLEY

In addition to the prominent varieties of barley originated by selection at our College, a considerable amount of work has been done in cross-fertilization, and thousands of hybrid plants are being examined annually. Some of the principal crosses have been between the Chevalier and the Mandscheuri; the Success and the O.A.C. No. 21; the Lion and the O.A.C. No 21, etc. Some of the objects have been (1) to secure a high-yielding, late-maturing six-rowed barley which might be grown satisfactorily in combination with a late oat such as the O.A.C. No. 72, the O.A.C. No. 144, or the Banner; (2) to secure a high-yielding white, six-rowed barley, but with smooth awns; (3) to secure a high-yielding white, six-rowed barley free from awns. The crossing work has extended back over quite a number of years. While promising results in the cross-bred varieties have been obtained, none of these have as yet been introduced into general cultivation.

Within the past six years, ten varieties of barley have been added to our experiments. These, along with sixteen older varieties, make in all twenty-six different-named sorts which have been grown in our plots from three to six seasons, within the years 1921 to 1926, inclusive. These have included the following six-rowed barleys: Arlington Awnless, Trebi, Lion, Wisconsin Pedigree, White Swiss No. 783, Minnesota No. 184, Bearer, Ottawa 475 and Featherstone; and the following two-rowed: Duckbill Ottawa No. 57, and New Alpha. Of these varieties the only ones which seem really promising in yield in the results for the last three to six years are the Trebi and Lion. The Lion, although smooth-awned, is a black, coarse barley more valuable for plant-breeding than for commercial purposes. Both varieties are very short in the straw and will probably never become valuable commercial varieties when grown under Ontario conditions. These two barleys were originated from selections made through the co-operation of the United States Department of Agriculture and the Minnesota Agricultural Experiment Station, the former from seed secured from Asiatic Turkey in 1905, and the latter from seed obtained from Southern Russia in 1911.

VARIETIES OF HULLESS BARLEY

Hulless barley has been grown to a limited extent in Ontario for a good many years. The most common variety which has been used in general cultivation in this province has been the Black Hulless.

Four varieties of hulless barley have been under test at the College for about a third of a century. The following table gives the average results of each of these four varieties for thirty-three years:—

Varieties	Weight per measured bushel (lbs.)	Yield per Acre	
		Straw (tons)	Grain (bushels by weight)
Guy Mayle	60.65	1.58	43.94
Purple	63.07	1.64	42.76
Black Hulless	62.55	1.64	41.96
Winnipeg No. 2	57.89	1.70	38.78

The Guy Mayle variety which heads the list in average yield of grain per acre, has been distributed, along with the Black Hulless variety, for co-operative experiments throughout Ontario in each of the past twenty-three years, during which time there has been a total of 270 successfully-conducted experiments. In the average of the twenty-three-year period, the Guy Mayle produced 23.9 and the Black Hulless 23.3 bushels per acre. Hulless barleys are, as a class, rather weak in the straw, but the Guy Mayle has straw of a medium strength.

WINTER BARLEY

Winter barley is not grown as a commercial crop in Ontario. Experiments have been conducted at the College, however, with several varieties of winter barley obtained from different sources. The Wood's Winter Barley has now been sown, ripened and harvested in each of thirty years between 1894 and 1926, inclusive. In the years 1895, 1896 and 1899 the crop was an entire failure, owing to winter killing. Those three years, however, occurred within the first six years of the experiment. There has been no complete failure with the crop since 1900.

The average yield per acre for the thirty years has been 48.9 weighed bushels per acre, and the weight per measured bushel has been 48.4 pounds, and the annual yield of straw per acre 1.2 tons.

In the last nineteen years from 1908 to 1926, inclusive, two varieties of winter barley have been under test under uniform conditions. The following gives the average results for the nineteen-year period:—

Varieties	Weight per measured bushel (lbs.)	Yield per Acre	
		Straw (tons)	Grain (bushels by weight)
Tennessee Winter Barley	49.20	1.20	45.58
Wood's Winter Barley	47.17	1.18	44.56

It will be seen that the Tennessee Winter, which has been grown for the last nineteen years, has given slightly higher yields than the Wood's Winter Barley, which has been grown at the College since 1908. In 1926, each of these two barleys yielded at the rate of over sixty bushels per acre.

VARIETIES OF WINTER WHEAT

Upwards of three hundred varieties of winter wheat and many selections and sses originated at Guelph have been grown under experiment at the Agricul- al College within the past thirty-six years.

In 1926 there were 807,015 acres of winter wheat grown in Ontario, producing practically twenty-one million bushels. With the exception of oats, winter wheat was the most extensively grown cereal in the province. In 1925, the last year for which this information is furnished in the agricultural reports, we learn that the market value of the fall wheat crop was upwards of $30,000,000.

Of the named varieties of winter wheat, fourteen have been grown under experiment at our College for thirty-one years, and the results of these are of special value. The following table gives for each of these fourteen varieties, the average weight per measured bushel for thirty years, and the average yield of both straw and grain per acre for the thirty-one-year period:—

Varieties	Colour of grain	Pounds per measured bushel (average 30 years)	Yield per Acre Average 31 years	
			Straw (tons)	Grain (bushels by weight)
Dawson's Golden Chaff	White	59.9	2.8	50.8
Imperial Amber	Red	61.1	3.2	49.2
Early Red Clawson	Red	59.1	2.7	47.2
Early Genesee Giant	White	60.0	2.9	46.9
Egyptian Amber	Red	61.4	3.0	46.9
Rudy	Red	61.1	2.8	46.1
Tasmania Red	Red	61.3	2.9	46.0
Tuscan Island	Red	61.2	2.8	45.6
McPherson	Red	61.3	2.6	45.0
Turkey Red	Red	61.3	2.8	44.9
Kentucky Giant	Red	61.0	2.7	44.7
Geneva	Red	61.6	2.9	44.2
Bulgarian	White	60.8	2.8	43.8
Treadwell	White	59.6	2.7	41.7

The average results of the fourteen varieties for the whole period of thirty-one years are as follows: yield of grain per acre, 46.0 bushels; yield of straw per acre, 2.8 tons; and weight per measured bushel, 60.8 pounds.

The Dawson's Golden Chaff was originated in Ontario forty-five years ago, by Mr. Robt. Dawson, a farmer living in Waterloo County. He had a field of the old Clawson wheat which was badly lodged as the result of a severe storm. In looking over the field he found one plant which seemed exceptionally stiff in the straw even under the trying conditions. He saved the seed from this one plant, which became the foundation of the Dawson's Golden Chaff variety, which is still the most extensively grown winter wheat in Ontario. In the average results at Guelph for thirty-one years, the Dawson's Golden Chaff gave 1.6 bushels per acre over the next highest-yielding variety, and 9.1 bushels per acre over the lowest yielder of the fourteen varieties included in the test, all of which were grown under similar conditions.

The Dawson's Golden Chaff has a very stiff straw, beardless head, red chaff, white grain, and is a very high yielder. This, being a white soft wheat, is used extensively in Ontario for the manufacture of pastry, shredded wheat and other breakfast foods. It is also used in blends with hard western wheat for bread production.

The Imperial Amber has a tall straw of fair strength, bearded head, red chaff, red grain which weighs the heaviest per measured bushel of all varieties tested at Guelph within the last dozen years. It is a high yielder of grain of fairly good quality, which is used for bread production.

The following table gives the average results of each of twenty-eight varieties grown under test in each of the last seven years:—

Varieties	Be. = Bearded Ba. = Bald	Colour of grain	Average height (inches)	Lbs. per measured bushel	Yield per Acre	
					Straw (tons)	Grain (bushels by weight)
Dawson's Golden Chaff (O.A.C. 61)	Ba.	White	43.0	60.6	3.0	62.3
O.A.C. No. 104	Ba.	White	45.4	61.5	3.3	61.3
Imperial Amber (O.A.C. 92)	Be.	Red	48.0	62.5	3.4	57.8
Red Rock	Be.	Red	43.4	62.3	3.0	57.7
Imperial Amber	Be.	Red	45.0	61.4	3.6	57.2
Yaroslaf, 5628	Be.	Red	44.3	60.9	3.4	56.9
No. 6 or Gold Coin	Ba.	White	41.9	60.6	2.6	56.8
Dawson's Golden Chaff	Ba.	White	41.9	60.7	2.7	56.2
McPherson	Ba.	Red	41.6	61.7	2.7	56.2
Abundance	Ba.	White	42.1	59.5	2.7	55.4
Early Red Clawson	Ba.	Red	43.0	60.2	2.8	54.7
Kanred No. 762	Be.	Red	38.9	63.0	2.7	54.5
Tasmania Red	Be.	Red	45.6	60.4	3.2	54.1
Rudy	Be.	Red	44.3	61.3	3.2	53.7
Manitoba Red Fife	Ba.	Red	42.4	61.8	2.8	53.0
Tuscan Island	Be.	Red	44.0	61.5	2.9	53.0
Egyptian Amber	Be.	Red	45.0	61.9	2.9	52.8
Turkey Red	Be.	Red	43.6	61.1	3.1	52.6
Kentucky Giant	Be.	Red	42.3	61.9	2.9	52.5
Crimean Red No. 5635	Be.	Red	42.7	61.4	3.1	52.3
Kharkov	Be.	Red	43.7	62.5	3.0	52.3
Banatka	Be.	Red	41.1	61.6	2.9	52.1
Buda Pesth	Be.	Red	43.0	61.8	3.0	52.1
Michigan Amber	Be.	Red	44.4	61.7	3.0	51.9
Early Genesee Giant	Be.	White	42.4	60.3	2.8	51.5
Bulgarian	Be.	White	45.1	61.7	2.8	51.3
Geneva	Be.	Red	44.0	61.5	3.0	50.1
Treadwell	Be.	White	43.1	59.6	2.6	44.3

The Dawson's Golden Chaff (O.A.C. 61) is a pure line selection from the Dawson's Golden Chaff. It will be seen that this new selection, started from a single seed, has given, in the last seven years, an average of fully six bushels per acre over the old variety. It is slightly taller and yields annually about one-third of a ton of straw per acre more than the old Dawson's variety. In the seven years' test the Dawson's Golden Chaff (O.A.C. 61) had less lodging than any other variety or strain under test.

The O.A.C. No. 104 is a College-bred variety, originated at Guelph by crossing the Dawson's Golden Chaff and the Bulgarian. It is a white wheat with a white chaff, similar to the Bulgarian, and has a beardless head similar to the Dawson's Golden Chaff. It is a vigorous grower, and has been more hardy even than the Dawson's Golden Chaff, but is not quite as stiff in the straw, but possesses grain somewhat richer in gluten.

The Imperial Amber (O.A.C. 92) is a pure line selection, made at the College from the Imperial Amber, which it surpasses slightly in yield and in quality of grain.

The Red Rock winter wheat was imported from the Michigan Agricultural College in 1917, and has been grown in our experimental grounds since that date. It is grown considerably in the State of Michigan.

The variety of winter wheat known as No. 6 closely resembles in appearance the Dawson's Golden Chaff, except that the head is less tapering and the upper portion of the straw is somewhat coloured. This wheat is also grown under the name of Gold Coin, with which it is claimed, by some authorities, to be identical.

In each of the past nine years, five varieties of winter wheat have been distributed throughout Ontario for co-operative experiments through the medium of the Experimental Union. The average of two hundred and two successfully conducted experiments in different parts of the province for the five-year period are as follows:—

Varieties	Yield per Acre (bushels by weight)	
	1926	Average 9 years
O.A.C. No. 104	29.41	28.33
Dawson's Golden Chaff (O.A.C. 61)	28.62	27.25
Imperial Amber (O.A.C. 92)	29.03	26.46
Yaroslaf	24.26	22.52
Kharkov	21.49	21.49

It will be seen that over the province the O.A.C. cross-bred variety has given fully a bushel per acre over the O.A.C. selected strain of the Dawson's Golden Chaff.

The Kharkov variety, which has given the lowest yield of the five varieties throughout Ontario, occupied twenty-first place of the twenty-eight varieties that have been grown at the College for the past seven years. It is a Russian wheat, imported through the United States Department of Agriculture, and has been under test at the College for the past seventeen years. It is a hard wheat of good milling quality, but is rather weak in the straw, having an average of eighteen per cent. lodged while the Dawson's Golden Chaff (O.A.C. 61) had no lodging in the average results of the last seven years.

Five new varieties of winter wheat have been introduced into the experiments within the past seven years, namely, Michikoff, Trumbull, Ohio 8106, Gladden and Berkley Rock. None of these, however, have equalled by a considerable margin the Dawson's Golden Chaff (O.A.C. 61) in yield of grain. Fuller reports will likely be made on these varieties in a few years as they have been tested at the College, up to the present time, for not more than three seasons.

A Field of O.A.C. No. 104 Winter Wheat.

QUALITY OF WINTER WHEAT FOR BREAD PRODUCTION

In each of eighteen years, the varieties of winter wheat grown under experiment in the Field Husbandry Department, were carefully tested for bread production in the bakery branch of the Chemical Department at the College. Those varieties of winter wheat which produced the largest loaves of bread from equal quantities of flour in the average tests made throughout the whole period, are given in the following order: Yaroslaf, Buda Pesth, Banatka, Tasmania Red, Crimean Red, Tuscan Island, Egyptian Amber, Treadwell, Kentucky Giant, Turkey Red; and those which produced the smallest loaves were Abundance and Early Red Clawson.

NEW O.A.C. CROSS-BRED VARIETIES OF WINTER WHEAT

It is interesting to know that of the thirty-six varieties of winter wheat under test at the College in each of the past seven years, the eight kinds which gave the highest average yields per acre were produced at our College by cross-fertilization and by selection. Six of these are hybrids, five of which have not as yet been introduced into general cultivation throughout the province. The varieties used as parents for these crosses were Dawson's Golden Chaff, Bulgarian, Imperial Amber, and Turkey Red. Some other varieties, however, have been included in other cross-fertilization work and some interesting new and valuable College-bred varieties should be ready for introduction in future years.

OTHER WINTER WHEAT EXPERIMENTS

An experiment has been carried on for twenty-nine years in which two varieties of winter wheat were each cut on five different dates, allowing one week between each two dates of cutting. The third or the middle cutting took place when the wheat was at about the same ripeness as it usually is under ordinary harvesting conditions when cut throughout the province. The first cutting took place at about two weeks and the second cutting about one week earlier than wheat is usually cut. When the fourth cutting took place the grain was usually fully ripe, and at the time of the fifth or last cutting it was in that condition which is sometimes spoken of as "dead ripe." The grain taken from each of these cuttings was used for sowing in the following year. It will, therefore, be seen that in each year the crops which were cut at different stages were grown from seed produced from similar cuttings of the year previous. The following table gives the average results for the twenty-nine-year period:—

Cuttings	Weight per measured bushel (lbs.)	Yield of Grain per acre (bushels by weight)
First	47.9	24.37
Second	57.0	39.90
Third	60.0	48.92
Fourth	60.0	51.15
Fifth	58.8	49.71

These results seem to indicate that for the largest yield of grain it is wise to use fully-matured seed, and to allow the crop to become fully ripened before it is cut. It will also be seen that the highest weight per measured bushel is from the third and fourth cuttings.

In the Experimental Department, winter wheat which has been grown on clover sod has yielded much better than that which has been grown on timothy sod.

In the average of eight separate tests, land on which field peas were used as a green manure yielded 6.5 bushels of wheat per acre more than land on which buckwheat was used as a green manure.

VARIETIES OF SPRING WHEAT

The acreage of spring wheat in Ontario decreased from 1922 to 1924, and since that date there has been an increase, the acreage in 1926 being 115,494 as compared with 101,401 in 1924. The acreage of spring wheat, therefore, is now somewhat higher than that used for either rye or peas. Upwards of two million bushels were produced in the province last year.

Many varieties of spring wheat, including all of the eight species or types of wheat included in the accepted botanical classification of this crop, have been under test. The following table gives the average results of each of eleven varieties of spring wheat grown under experiment for a period of fourteen years:

Varieties	Height (inches)	Days to maturity	Per cent. rust	Weight per measured bushel (lbs.)	Yield per Acre	
					Straw (tons)	Grain (bushels by weight)
O.A.C. No. 85	43	115	6	60.3	2.03	33.28
Climax	42	116	8	59.5	2.06	32.13
Saxonka	43	117	8	60.5	1.98	31.71
Marquis	36	113	8	61.0	1.72	31.62
Hungarian	38	111	6	62.0	1.82	31.07
Pringle's Champion	44	117	8	60.4	1.97	30.97
Herison Bearded	41	116	6	61.1	1.98	30.72
White Fife	39	118	8	58.2	1.88	29.98
Red Fife	40	115	7	59.9	1.89	29.89
Colorado	42	115	7	60.0	1.81	28.25
Prelude	30	103	7	61.7	1.23	21.08

Not only did the O.A.C. No. 85 variety of spring wheat come the highest in average yield of grain per acre for the fourteen-year period, of the flour spring wheats here presented, but it has also surpassed in yield the different varieties of durum or macaroni spring wheats, including the Wild Goose, which are considered high yielders, but are quite inferior for bread production to the O.A.C. No. 85.

The O.A.C. No. 85 spring wheat was originated at Guelph by crossing the Red Fife and the Herison Bearded, the latter variety being an importation from France. It is a fairly tall, medium-ripening variety of spring wheat with a medium long, somewhat open, white-chaffed bearded head, and a very heavy yielding red grain of good quality.

In each of the past two years an experiment has been conducted by sowing the O.A.C. No. 85, the Marquis and the Early Red Fife at 1, 1¼ and 1½ bushels per acre.

Varieties	Weight per measured bushel (lbs.) average 2 years	Yield per Acre			
		Straw (tons) average 2 years	Grain (bushels by weight)		
			1925	1926	Average 2 years
O.A.C. No. 85	61.04	1.50	29.76	26.82	28.29
Marquis	61.75	1.31	28.56	23.91	26.24
Early Red Fife	61.09	1.20	18.86	22.78	20.82

The Marquis variety of spring wheat originated at the Central Experimental Farm, Ottawa, by crossing the Calcutta Hard Red and the Red Fife. It is not only a good yielder, but it is a wheat of excellent quality for bread production, producing large white flaky loaves of bread which are exceptionally popular. This wheat is now grown very extensively in the western provinces and in the western states, occupying more acres than any other variety of spring wheat grown on the American continent. This wheat is a great practical demonstration of what science can do for agriculture when applied in the right direction.

The Early Red Fife is a pure line selection from the old Red Fife variety also made by Dr. Chas. E. Saunders, formerly cerealist at the Central Experimental Farm, Ottawa.

Within a period of fourteen years the Wild Goose and Marquis varieties of spring wheat have been successfully tested throughout Ontario on 165 farms, the average yield per acre of the former being 20.3 and of the latter 19.2 bushels. The Wild Goose is a hardy, flinty wheat, and belongs to the durum species. It is better suited for the manufacture of macaroni than for bread production. The Marquis variety is now the most extensively grown spring wheat in Ontario. The O.A.C. No. 85 variety of spring wheat has been used in the co-operative experiments for the last three years.

Varieties	Yield per Acre (bushels)			
	1924	1925	1926	Average 3 years
O.A.C. No. 85	31.1	21.1	15.3	22.5
Wild Goose	26.3	18.5	14.1	19.6
Marquis	24.3	19.3	14.6	19.4

It will be seen that the O.A.C. No. 85 which was originated at Guelph through cross-fertilization, occupies the very highest place in yield of grain per acre, in both the regular and the special experiments at Guelph, and in the co-operative experiments conducted by farmers throughout Ontario.

VARIETIES OF DURUM SPRING WHEAT

That variety of durum or macaroni wheat which is the best known in Ontario is the Wild Goose variety. This wheat has been grown in this province quite extensively for many years past. It belongs to the type of wheat placed in the botanical classification as hard or flinty wheat (Triticum durum). The wheats belonging to this type are grown quite extensively in the semi-arid regions in the central-western part of the United States. The varieties of this type of wheat are very hard and require much power to grind them into flour. There is not a very clear separation of the bran from the flour which usually has a yellowish colour. Especially is this true of the Wild Goose variety which, however, is being used more and more for flour production, the flour being used to mix with that of the softer varieties of winter wheat which are grown in Ontario. Five varieties of macaroni or durum wheats have been grown in the experimental plots at the College for the thirteen years from 1914 to 1926, inclusive.

Varieties	Weight per measured bushel (lbs.)	Yield per Acre	
		Straw (tons)	Grain (bushels by weight)
Arnautka 1537	62.0	1.85	33.13
Roumania	62.1	1.86	33.00
Kubanka	61.2	1.94	32.06
Wild Goose	61.4	1.86	31.37
Medeah	60.8	1.69	28.16

The Wild Goose spring wheat, which is the best-known durum wheat in Ontario, occupies fourth place in average yield of grain per acre for thirteen years. The Arnautka is a wheat resembling the Wild Goose quite closely in some characteristics, but in yield per acre and in weight of grain per measured bushel the Arnautka has made a very excellent record for the whole period.

It is interesting to note that in the whole fourteen-year period the O.A.C. No. 85 variety of spring wheat surpassed even the Arnautka 1537, which is the highest yielder of all the durum wheats. The former gave an annual average of 33.28 and the latter 33.13 bushels of grain per acre.

EMMER AND SPELT FOR THE PRODUCTION OF GRAIN FOR FEEDING PURPOSES

The wheats already described representing three types or species, have a distinct separation of grain and chaff at the time of threshing. Three of the other four species, however, two of which are represented by the Emmer and the Spelt, do not have a clear separation of grain and chaff on being threshed. After the crop has been threshed the grain is still surrounded by the chaff, and these two are usually ground together for the production of meal for feeding purposes. Although both Emmer and Spelt have been grown at the College more or less for about thirty years, the last-named grain is scarcely ever grown on the farms of Ontario. Emmer has been grown as a field crop in many sections, although it is even yet in some parts of province improperly called Spelt. Each of these types of wheat is represented by a number of varieties. The following table gives the average of sixteen years' results of each of three varieties of Emmer, and three varieties of Spelt which have been grown at the College:—

Classes of Crop	Varieties	Per cent. rust	Per cent. lodged	Per cent. hull	Weight per measured bushel (lbs.)	Yield per Acre	
						Straw (tons)	Grain (lbs.)
Emmer...........	Emmer No. 1529...	2	16	19.97	38.75	1.83	2,617
	Common.........	2	22	20.43	39.22	1.81	2,569
	Russian..........	2	18	20.43	38.94	1.70	2,546
Spelt.............	Red.............	10	5	28.79	27.31	1.43	1,944
	Alstroum.........	13	3	29.45	26.81	1.40	1,927
	Triticum.........	10	12	26.81	28.49	1.46	1,874

Some seedsmen imported emmer a few years ago and sold it under the name of spelt, and this was advertised very extensively both in Canada and in the United States, and most extravagant claims were put forward for this grain. The results of experiments conducted at Guelph are of value in giving true and reliable information regarding the two species of grain and the comparative results of some of the varieties of each type. It will be seen that each of the three varieties of emmer gave a much higher average yield of both grain and straw per acre than any of the three varieties of spelt. The percentage of hull of emmer is only two-thirds as great as that of spelt. It is also only about two-thirds as great in percentage of hull as the average variety of oats. Emmer has been a close rival to the best varieties of barley and the best varieties of oats in grain production. In the average results at the College, the O.A.C. No. 21 barley has surpassed the Emmer No. 1529 by about 200 pounds of grain per acre annually.

The O.A.C. No. 21 barley and Common Emmer have been under competition throughout Ontario in each of the past fourteen years during which time 158 farmers have conducted distinct experiments and reported the records satisfactorily. In the average of this period barley surpassed emmer in yield of grain per acre per annum, by 282 pounds.

Emmer No. 1529, Common Emmer and Red Spelt have each been under experiment at the College for a period of twenty-one years, from 1906 to 1926, inclusive. For that whole period the average number of pounds of grain produced per acre was 2,682 for Emmer No. 1529; 2,597 for Common Emmer, and 2,014 for Red Spelt.

The Emmer No. 1529 was imported from the Agricultural Experiment Station, Brookings, South Dakota, in the spring of 1906.

WHEATS OF OTHER SPECIES

We have already dealt with five species of spring wheat which are represented by varieties in the former tables as follows: Common (triticum vulgare) by O.A.C. No. 85 and all the varieties in that list with the exception of Herison Bearded, which has a compact headed variety (triticum compactum); hard or flinty (triticum durum); emmer (triticum dicoccum); and spelt (triticum spelta). There are still three species or types of wheat of which we have one variety of each, namely, Seven-headed, belonging to the type Turgid or Toulard (triticum turgidum); Polish, belonging to the type Polish (triticum Polonicum); and One-Grained Wheat, belonging to the type One-Grained (triticum monococcum). We have had each of these three types under test in each of the past thirteen years and the following gives the average annual yield per acre for the whole thirteen-year period: Seven-headed, 25.16 bushels; Polish, 20.36 bushels; One-Grained Wheat, 1,952 pounds. The last-named variety is somewhat similar to emmer and spelt, not having a clear separation of the chaff and the grain in the process of threshing. It will be seen that each of these varieties has given considerably less yield of grain per acre than the other types reported previously. Both the Polish and the Seven-headed types of wheat have been extensively advertised in past years, the former under the name of Corn Wheat, and the latter under the name of Miracle and Alaska. Seed was offered for sale at very high prices, sometimes reaching $20.00 per bushel. If growers would watch results of experiments, they could frequently avoid mistakes in buying seed of poor varieties at extravagantly high prices.

QUALITY OF SPRING WHEAT FOR BREAD PRODUCTION

In each of thirteen years the different varieties of spring wheat under experiment at the College have been tested for bread production in the bakery branch of our Chemical Department. The different varieties have been milled and uniform quantities of flour of each kind have been used for bread production. Careful data have been accumulated regarding wet and dry gluten, absorption, yield, volume, colour, texture, etc. For this report simply the comparative size of loaf will be given. The following gives the average results for the last nine years of the comparative size of loaf of the common and the durum wheats which have been tested under uniform conditions: White Fife, 99.6; Marquis, 98.3; Hungarian, 94.8; O.A.C. No. 85, 90.2; Wild Goose, 88.3; Kubanka, 88.1; Saxonka, 87.9; Climax, 87.8; Arnautka (1537), 87.4; Red Fife, 87.2; Herison Bearded, 86.5; Pringle's Champion, 85.4; Colorado, 80.4; Roumania, 71.5; Medeah, 69.6.

These results show that four varieties, namely, White Fife, Marquis, Hungarian and O.A.C. No. 85 have given over ninety, while other varieties give as low as 69.6 in comparative size of loaf from uniform quantities of flour. The Marquis and the White Fife were particularly high, and the Hungarian and O.A.C. No. 85 show themselves to be good wheats for bread production in the average results for nine years.

It is particularly interesting to note that the O.A.C. No. 85, the highest yielder of all varieties, has also given a greater bread production than the old Red Fife variety which was the noted spring wheat of a few years ago.

VARIETIES OF WINTER RYE

In 1926 there were 97,865 acres of rye grown in Ontario. This includes the rye which was sown in the spring as well as that which was sown in the autumn. The latter, however, comprises the greater part of the rye crop of the province. Three varieties of winter rye have been under test at the Ontario Agricultural College in each of the past twenty-three years. The following table gives the average results for the whole period:—

Varieties	Per cent. of crop lodged	Weight per measured bushel (lbs.)	Yield per Acre	
			Straw (tons)	Grain (bushels by weight)
Mammoth White	13	57.0	3.85	56.13
Washington	22	57.0	3.76	54.49
Common	17	56.7	3.82	53.56

The average results for twenty-three years show that winter rye gives a high yield of grain per acre in Ontario. When we recognize the fact that the winter rye was grown on similar soil to that used for the other cereals it will be understood that the rye as grown at the College is usually on better soil and under more favourable conditions than when grown on the average farm of Ontario, where rye is frequently sown on poor soil and under adverse conditions in various ways. If winter rye were sown under the same conditions as winter wheat over Ontario, the yields per acre would undoubtedly be higher than they are at the present time.

In each of the past nine years seven varieties of winter rye have been under test. As two important varieties have been added the results for the nine-year period which follows are very interesting.

Varieties	Per cent. of crop lodged	Weight per measured bushel (lbs.)	Yield per Acre	
			Straw (tons)	Grain (bushels by weight)
Rosen	28	56.70	3.86	66.57
New Invincible	29	56.94	3.65	64.95
Washington	24	56.69	3.87	56.79
Mammoth White	16	56.78	3.84	56.72
Common	28	56.79	3.81	56.02

These results bring out prominently the value of the Rosen and New Invincible varieties, especially the former. In the yearly results, however, the Rosen gave the highest yield per acre of the five varieties in each of four and the New Invincible in each of five years. The results of these new varieties show greater possibilities for rye-growing in Ontario. The Rosen variety was imported from Michigan Agricultural College. It has made a very excellent record at that institution, and also throughout the State of Michigan.

VARIETIES OF SPRING RYE

Spring rye is not grown as extensively in Ontario as that which is sown in the autumn. Some farmers, however, grow a limited quantity of this crop. The following table gives the average results of each of three varieties grown under experiment for eighteen years:—

Varieties	Weight per measured bushel (lbs.)	Yield per Acre	
		Straw (tons)	Grain (bushels by weight)
Saatroggen Petkus	54.75	2.08	30.8
O.A.C. No. 61	54.62	2.01	30.0
Common	54.70	1.90	27.7

In 1901 the writer visited one of the greatest rye breeders in Germany, and secured some seed of winter rye from him. This was gradually converted into a spring rye in the experimental grounds at Guelph, and it is the one which now occupies highest place in the results here presented. O.A.C. No. 61 is a special selection from the same variety.

In 1921 a variety of spring rye now named the White Giant was obtained and this has now been grown in the plots in each of six years. In every instance, however, the yield per acre was lower than each of the three varieties here reported, the average being more than four bushels per acre below the lowest-yielding variety for the six-year period.

VARIETIES OF BUCKWHEAT

In 1926 there were 234,870 acres of buckwheat grown in Ontario. This is nearly 100,000 acres more than the average annual area devoted to this crop for the past forty-five years. The following table gives the average results of twenty-one years' tests with each of four varieties of buckwheat grown in the Field Husbandry Department:—

Varieties	Weight per measured bushel (lbs.)	Yield per Acre	
		Straw (tons)	Grain (bushels by weight)
Rough	48.58	2.27	33.82
Japanese	45.94	3.04	26.33
Common Grey	45.93	2.94	26.27
Silver Hull	49.12	3.92	24.81

A study of the detailed results show that the Rough Buckwheat surpassed each of the other three varieties in yield of grain per acre in each of fifteen out of the twenty-one individual years. The Rough Buckwheat has an irregular grain, fairly thick hull, and flour with a yellowish tinge, which has a slightly bitter taste. The Rough and Silver Hull varieties have been distributed over Ontario for co-operative experiments through the medium of the Experimental Union, in each of the past fifteen years. As the average result of fifty-five successfully-conducted tests on the different soils of Ontario, it has been ascertained that the Rough Buckwheat gave 26.5 and the Silver Hull 21.1 bushels per acre per annum.

VARIETIES OF FIELD PEAS

Field peas are an important crop in some sections of Ontario. In 1926, 1,880,301 bushels of peas were produced in the province. The following table gives the average results of each of seven varieties of field peas grown at the College under experiment in each of the past twenty-seven years:—

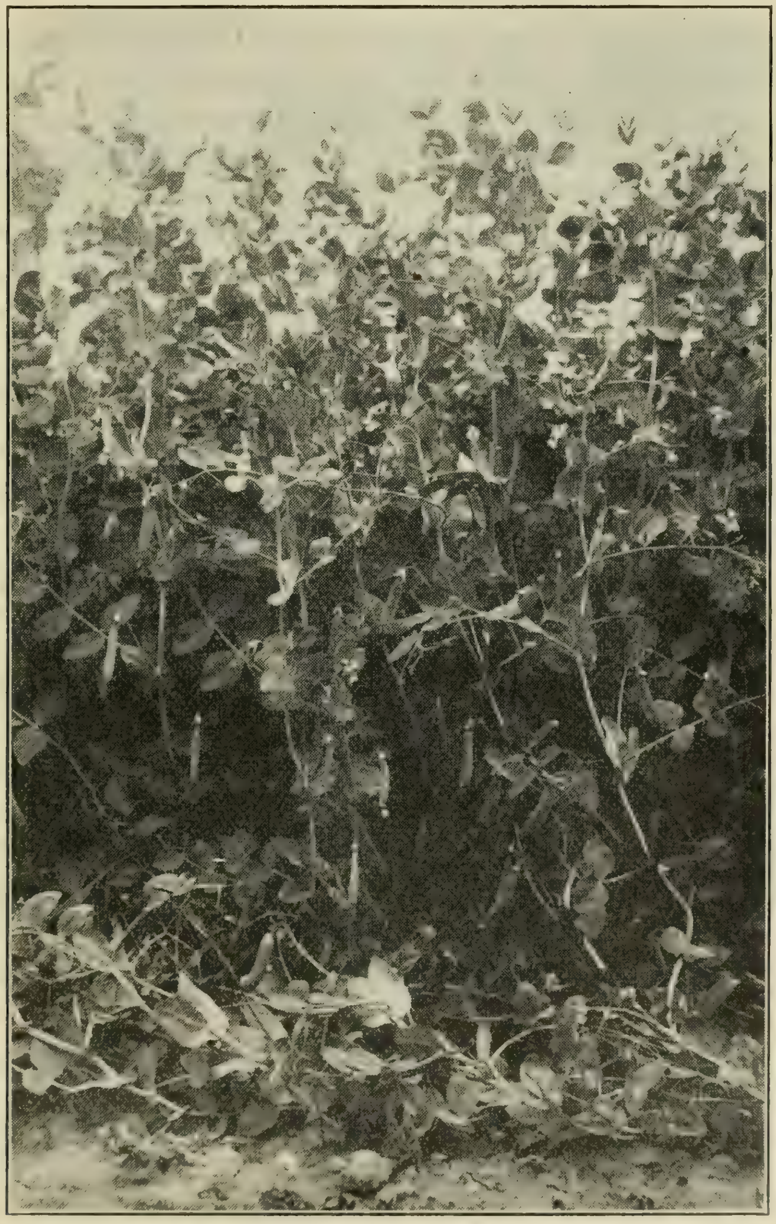
Varieties	Weight per measured bushel (lbs.)	Yield per Acre	
		Straw (tons)	Grain (bushels by weight)
Potter	60.5	1.51	35.35
Early Britain	58.8	1.55	34.80
Black-Eyed Marrowfat	60.6	1.56	32.40
Canadian Beauty	61.5	1.56	31.39
Prussian Blue	61.4	1.70	27.39
Golden Vine	61.7	1.60	26.20
Multipliers	61.8	1.70	26.11

The Potter is a large white pea of good quality which is grown only to a very limited extent in Ontario. The Early Britain is a brown pea imported by the College from England many years ago. The Golden Vine is a small, smooth, white pea, which in former years was the common pea of Ontario.

The following table gives the average results of each of eleven varieties of field peas for the nine years from 1918-1926, inclusive:—

Varieties	Days to mature	Length of vine (inches)	Per cent. injury by Pea Weevil	Weight of 1,000 peas (ozs.)	Weight per measured bushel (lbs.)	Yield per Acre	
						Straw (tons)	Grain (bushels by weight)
O.A.C. No. 181	102	44	7	6.9	63.1	1.66	43.41
Shannon	102	45	18	11.6	56.4	1.54	39.95
Potter	106	47	5	10.3	61.9	1.71	38.89
White Wonder	100	25	6	9.2	63.2	1.36	38.84
Black-Eyed Marrowfat	110	50	7	10.8	61.6	1.80	37.00
Early Britain	107	46	5	10.3	60.4	1.81	36.80
Arthur	107	44	4	9.8	63.1	1.56	35.79
Canadian Beauty	108	50	8	12.9	62.6	1.82	34.62
Prussian Blue	112	53	9	7.8	63.0	1.86	29.06
Multipliers	111	53	4	7.0	63.4	1.74	28.85
Golden Vine	111	55	5	7.2	63.4	1.79	26.67

By hand-crossing the White Wonder, an early, short-strawed, white-grained, high-yielding pea, from New Zealand, with the Prussian Blue, a long-strawed, medium-sized, later-maturing variety, the Ontario Agricultural College produced a new and very promising variety of field pea, which was named O.A.C. No. 181. It has a medium length of straw, is early, comparatively free from disease, and produces a very heavy yield of white peas, which are about the same size as those of the Golden Vine. In the experiments at the Colleg eat Guelph it has matured earlier than all other varieties of field peas commonly grown in Ontario, surpassing some of them from a week to ten days. The O.A.C. No. 181 field peas have been accepted recently for registration in Canada by the Canadian Seed Growers' Association.



New Hybrid Field Pea, O.A.C. No. 181.

The Shannon variety of peas, although a large yielder of grain, would not be a popular pea for the Ontario farmer. It is a large-sized brown pea, deeply indented, which does not weigh heavily per measured bushel. The pods are of a purplish colour immediately before ripening. In examining the peas annually, it is found that they are more subject to the ravages of the pea weevil than any of the other varieties under test.

The O.A.C. No. 181 and the Canadian Beauty varieties have been tested in a special experiment in which two, two and one-half, and three bushels of seed were sown per acre in each of the past three years. The average results of the three tests are as follows for each of the years referred to:—

Varieties	Yield of Grain per Acre (bushels by weight)			Average, 3 years
	1924	1925	1926	
O.A.C. No. 181	31.5	41.4	52.7	41.85
Canadian Beauty	21.3	23.2	40.6	28.36

It will be seen that the O.A.C. No. 181 variety of peas surpassed the new Canadian Beauty in the triplicate experiments conducted in each of the past three years, the average difference being 13.49 bushels per acre per annum in favour of the new hybrid variety.

A total of 132 successfully-conducted co-operative tests have been made during the past five years with four varieties of field peas. The average yields in bushels per acre for 1926 and for the whole period are as follows:—

Varieties	Yield per Acre (bushels)	
	1926	Average, 5 years
O.A.C. No. 181	24.09	24.91
Potter	23.94	23.83
Early Britain	23.16	22.88
Canadian Beauty	22.17	22.55

In each of four years the O.A.C. No. 181 variety gave the highest yield per acre, and in 1924 was second in yield per acre. In 1926, although the Canadian Beauty variety was lowest of the four varieties tested in yield per acre, it was next in popularity to the O.A.C. No. 181.

O.A.C. BRED AND OTHER NEW VARIETIES OF FIELD PEAS

Hybridization at our College has resulted in the production of four cross-bred varieties which have given the four highest average yields of grain per acre of all the varieties of peas obtained from various parts of the world, which have been under test at the College in the past nine years. The highest-yielder of all was a cross between the Prussian Blue and the White Wonder, the latter being imported from New Zealand. This cross received the name of O.A.C. No. 181 before it was distributed throughout Ontario for co-operative experiments. The next two highest-yielding varieties were obtained from crosses of the Early Britain and the White Wonder, and the fourth highest-yielding variety from crossing the New Zealand field pea and the Early Britain, the former imported from New Zealand and the latter from England some years ago. Three of these varieties have not as yet been named and introduced into general cultivation, but are being carefully tested, studied, and selected from year to year.

Of those varieties of peas which have been tested in our plots for less than nine years, we have had the following varieties in our regular experiments: Arthur Peas, Ottawa No. 18, and Chang Peas, five years; Abundance, Chancellor Ottawa 26, Mackay Ottawa 25, and Early Raymond, three years; and Farnhams, Khaba, Scotch Beauty, Qschang, and Early Blue, Ottawa 21, for one year only.

The O.A.C. No. 181 has given a higher yield per acre than each of these eleven newly-introduced varieties in the average results of the experiments up to date. When the experiments have been conducted for a sufficient length of time the results will undoubtedly be presented more in detail.

VARIETIES OF FIELD BEANS

Ontario now produces almost a million bushels of field beans annually. The average yield of field beans per acre per annum for the past forty-five years in this province has been 16.2 bushels. Those Ontario counties which had the greatest acreage of field beans in 1925, the last year for which we have the printed record, are given in the following order: Kent, Elgin, Huron, Middlesex, Welland, Lambton, and Norfolk. The market value of beans per acre for the past six years has been higher than that for any other grain crop, being even slightly greater than that of corn grown in the ear. The following table gives the average results of each of seven varieties of field beans grown under test at the College for the thirty years from 1897 to 1926, inclusive:—

Varieties	Yield per Acre (bushels by weight)
Pearce's Improved Tree	23.52
Schofield	21.47
Medium or Navy	20.91
White Wonder	20.77
Marrowfat	19.63
Small White Field	19.63
Large White Haricots	18.52

The beans here reported are all white in colour, and are all suitable for commercial purposes. The Pearce's Improved Tree bean, which comes at the head of the list is not grown very extensively in Ontario. It is a large white bean of excellent quality for cooking purposes. It is, however, a little later in reaching maturity than the different strains of the pea bean which is the great commercial bean of Ontario.

Twenty-two varieties of field beans have been tested in our experimental grounds in each of the past six years. As this table includes a number of new varieties and selections, the results are of special interest and are given as follows for the six-year period.

It will be seen that there is still room for work in bean improvement in Ontario as the average results for the past six years show the Common Pea Bean to head the list in average yield of grain per acre per annum. The Pearce's Improved Tree bean which has headed the list for a long period of time is surpassed in the six-years' test by about one and one-quarter bushels per acre. Several selected varieties from Michigan and Cornell Experiment Stations have been tested in our trial grounds, and are distributed throughout the list of results. It will be noticed that the Marrowfat and Red Kidneys are rather low yielders in comparison with the pea beans, or with the Pearce's Improved Tree bean.

Varieties	Height of plants (inches)	Beans per pod (number)	Weight per measured bushel (lbs.)	Yield per Acre	
				Straw (tons)	Grain (bushels by weight)
Common Pea	13.5	4.8	64.92	.83	31.13
Medium or Navy	14.0	4.3	64.36	.75	30.95
Small White Field (Wiley's No. 212)	15.2	5.4	66.31	.97	30.23
M. A. C. Robust	12.8	5.8	65.48	.81	30.07
Pearce's Improved Tree	13.7	4.0	63.00	.81	29.90
630411 (Mich. Agric. College)	13.0	5.8	65.83	.71	29.66
White Wonder	14.7	4.4	63.94	.86	29.41
Small White Field (Warwick's No. 211)	12.7	5.5	65.65	.74	29.32
New Prize Winner	14.5	4.6	65.19	.76	28.88
Schofield Pea	14.3	4.6	65.08	.79	28.64
Minnesota No. 147	12.8	5.2	65.38	.73	28.28
630519 (Mich. Agric. College)	13.0	5.7	65.77	.73	28.27
Small White Field	14.8	4.9	65.31	.83	28.22
630425 (Mich. Agric. College)	13.5	6.0	65.75	.70	27.91
1986-2 (Ithaca, N.Y.)	12.5	4.2	65.46	.69	27.30
Large White Haricots	15.0	4.1	61.86	.89	25.21
Well's Blight Proof Red Kidney	13.8	4.0	58.11	.77	24.53
Yellow Eyed Marrowfat (Moorehouse No. 211)	15.0	4.6	62.94	.70	24.52
Yellow Eyed Marrowfat	15.3	4.2	63.31	.73	24.01
Marrowfat	16.0	4.0	64.61	.83	23.71
Red Kidney	13.7	4.0	56.63	.72	21.97
White Kidney	13.5	3.6	61.44	.80	21.21

Our College has been carrying on work for some time with the object of improving the productiveness of beans by selecting individual plants and by trying to secure strains of varieties as immune as possible to the attacks of anthracnose and other diseases which are troublesome to the crop. No results are yet ready for publication.

In the co-operative experiments over Ontario through the medium of the Experimental Union, three varieties of beans have been successfully tested by farmers in each of the past seven years, during which time sixty-six good reports were received. The following gives the average annual yield in bushels per acre for the six-year period: Pearce's Improved Tree, 25.8; Michigan No. 630425, 24.1; and American Wonder, 22.9. The writer prepared a report on field beans which was issued in Bulletin No. 232.

VARIETIES OF SOY BEANS

We have tested in all fully one hundred varieties of soy beans, most of them for five years or over. The Early Yellow variety has been under test for thirty-one years, during which time it gave an average annual yield of grain per acre of 16.78 bushels, or 1,006.8 pounds. In a twenty-two-year test the average annual yield of grain per acre was 1,055 pounds for the Early Yellow Soy, and 950 for the Ito San. In another test, running for twenty-two years, the Early Yellow gave 5.9 and the Ito San 7.5 tons of green crop per acre per annum. It will be seen that from the strains of these varieties obtained over a quarter of a century ago, the Early Yellow was higher in production of grain and the Ito San in production of fodder.

Eight varieties of soy beans have been grown under similar conditions in each of the past fourteen years. The following table gives the average results for the fourteen-year period:

Varieties	Average height (inches)	Weight per measured bushel (lbs.)	Yield per Acre	
			Green fodder (tons)	Grain (bushels by weight)
Habaro No. 20405	26.2	57.53	7.99	20.38
O.A.C. No. 111	26.7	57.09	8.02	19.92
Tsurunoko	24.4	57.95	6.01	19.91
Early Yellow	24.1	57.29	6.04	19.81
Quebec No. 92	20.9	58.14	5.35	18.64
Brown	23.8	58.08	5.39	17.94
Ito San	26.9	57.97	7.96	17.30
Medium Green	29.9	.....	6.92	13.51

The Habaro was imported from the United States Department of Agriculture at Washington. It was first introduced in 1906 from Khabarovsk, Siberia.

The O.A.C. No. 111 was obtained through selection work from the Early Yellow variety, the latter being originally obtained from Dr. C. C. Georgeson, then connected with the Agricultural Experiment Station at Manhattan, Kansas. This was one of the leading varieties imported by Dr. Georgeson from Japan a few years previous.

The Tsurunoko variety, which is third on the list, was started nineteen years ago, from four ounces of seed which we obtained directly from the College of Agriculture, Sapporo, Japan.

The Quebec No. 92 was originated by selection by Dr. L. S. Klinck, when in charge of the agronomy work at Macdonald College, Quebec.

The Medium Green has been grown at the College for a long time, but owing to its late maturity does not give satisfactory results as a grain producer.

The following table gives the average results of each of thirteen varieties of soy beans grown at the College in the last five years:—

Varieties	Average height (inches)	Green fodder (tons)	Ripened Seed	
			Weight per measured bushel (lbs.)	Yield per acre (bushels by weight)
O.A.C. No. 211	28	10.28	58.8	28.10
Manchu	29	10.19	58.3	27.38
Tsurunoko	23	7.66	58.1	26.43
O.A.C. No. 111	24	9.73	58.1	25.97
Habaro	28	10.41	58.3	25.97
Early Yellow	23	7.44	58.1	25.82
Minnesota No. 167	29	9.63	58.4	25.50
Quebec No. 92	17	6.93	58.0	24.42
Ito San	27	9.87	58.4	22.63
Brown	20	6.54	58.2	22.18
Medium Green	31	9.29	58.0	20.88
Early Soja (Steele, Briggs)	29	5.64	*57.9	12.06
Early Soja (Bruce)	29	6.53	*58.0	10.46

*Average of three years only.

The O.A.C. No. 211 which stands highest in average yield of seed per acre and in weight per measured bushel, and second highest in yield of green crop per acre, has been grown in the plots for eight years, but in only the last six of these has it been included in the regular variety tests. In 1918, thirty-four special plants were selected from about ten thousand plants of the Habaro No. 20405 variety. Of the thirty-four selected plants the progeny of twenty-two were carefully tested under uniform conditions in 1919 and in 1920. In the two years' results the progeny of one of the plants gave higher results than that of any of the other twenty-one plants in weight per measured bushel and in yield of both straw and of beans per acre. This outstanding performer was transferred to the regular test plots in the spring of 1921 and has since been grown with all other varieties under the name of O.A.C. No. 211. This variety has now been accepted as eligible for registration by the Canadian Seed Growers' Association, the only variety of soy beans which has been so honoured.

An acre plot of O.A.C. No. 211 Soy Beans grown for grain.

The Manchu was imported into the United States in 1913 from Niguta, Manchuria, and was entered into our College tests in 1922, where it has been grown in each of the past five years. The Manchu has a black, and the O.A.C. No. 211 what is usually termed a yellow eye. Other than the colour of the eye, both of these varieties are of a beautiful yellow appearance.

In each of the past three years, twenty-six varieties of soy beans have been under test. In the average for the three years' experiment, the O.A.C. No. 211 heads the list with 1,821 pounds per acre per annum. This was followed by the Manchu as second variety, with 1,746 pounds, and the Tsurunoko third, with 1,587 pounds.

In the co-operative experiments throughout Ontario, the O.A.C. No. 211 has been distributed in each of four years. In 1925 and in 1926, it was compared with the Early Yellow, surpassing the latter-named variety by over one bushel of grain per acre per annum. In the three years from 1923 to 1925, inclusive, it was compared with the Brown variety, surpassing this variety by an average annual yield of grain per acre per annum of 4.35 bushels.

As each of twenty-six varieties of soy beans have been under test in our experimental grounds in the three years, 1924, 1925 and 1926, it introduces a number of new varieties which were not previously entered into the College experiments. The following table gives the average results of each of the twenty-six varieties for the three-year period:—

Varieties	Average height (inches)	Green fodder (tons)	Weight per measured bushel (lbs.)	Yield of grain per acre (lbs.)
O.A.C. No. 211	28.3	10.86	59.25	1,821
Manchu	31.0	10.50	58.83	1,746
North's	25.3	9.59	59.46	1,737
Black Ontario	21.0	7.53	59.75	1,734
Mandarin	24.3	8.81	58.96	1,699
Black Eyebrow (Jeffrey)	29.0	9.86	58.84	1,670
Habaro No. 20405	28.7	11.07	58.83	1,629
O.A.C. No. 111	27.7	9.96	58.75	1,618
Black Manchurian (Jeffrey)	21.0	7.37	59.80	1,588
Tsurunoko	23.7	7.94	58.59	1,587
Oyaji	23.3	8.39	58.63	1,525
Early Yellow	22.7	7.72	58.58	1,516
Quebec No. 92	20.7	7.22	58.54	1,512
Minnesota No. 167	30.0	10.09	59.13	1,509
Ito San	29.3	10.42	59.00	1,424
Brown	20.7	6.78	58.84	1,353
Shiro Kotsubu	25.7	7.12	59.71	1,260
Medium Green	31.0	9.40	58.59	1,178
Kuro-otsubu aka	27.7	7.54	56.88	1,159
Argyle (Jeffrey)	30.0	9.37	57.83	1,115
Early Soja (Bruce)	29.3	8.89	57.96	1,046
Ogemaw	15.7	5.56	57.21	976
Hollybrook (Jeffrey)	32.3	8.75	57.50	927
Chagara	11.3	2.61	.....	400
Wasa-Otsura	11.7	3.36	59.13	379
Washe Otuku	14.0	2.23	.....	289

It will be seen that the O.A.C. No. 211 variety stands at the head of the list in yield of grain, and second highest in yield of green fodder.

VETCHES FOR SEED PRODUCTION

The vetches are leguminous crops and furnish food which is rich in nutritive constituents. They are also valuable crops for growing on the land, and especially, when ploughed under, furnish valuable plant food rich in nitrogen.

The common vetches have been tested at the College, and when grown separately have usually proved a failure from the standpoint of seed production.

The hairy vetches are becoming rather an important crop in the province, not only as a fodder crop when grown alone or in combination with oats, or used for seed production, but also as a cover crop in the fruit-growing districts. The seed of hairy vetches in past years has been largely imported and is usually quite expensive, frequently costing from five to nine dollars per bushel. We have found through experiments that the seed can be grown in Ontario with a good deal of satisfaction. It can be sown in the spring or in the autumn, but the autumn seeding has been decidedly the most productive, frequently doubling the yield as compared with the spring seeding. The following table gives the average results for twenty-two years in comparing hairy vetch seed which was produced at the college in comparison with that which was imported:—

Seed	Yield per Acre	
	Straw (tons)	Seed (bushel, 60 lbs.)
Hairy Vetches (Canadian grown seed)	1.72	10.33
" " (Imported seed)	1.53	8.73

The table shows that when the hairy vetch is acclimatized in Ontario, quite a large yield of seed can be realized per acre, the average being over ten bushels per annum for a twenty-two year period. In each of the two years, 1924, and 1925, the yield was over eighteen bushels per acre, and in the years 1910 and 1911, it was over seventeen bushels per acre, while in 1913 no seed was obtained and in three other years, 1907, 1921 and 1922, the yield was from three and one-half to four bushels per acre per year.

Experiments have been conducted and are reported elsewhere in which hairy vetches have been sown with winter wheat, winter rye and winter emmer, also with spring wheat and with spring rye. In no case did the hairy vetches yield as heavily when sown with the grain crop as when the vetches were sown separately. It must be remembered that when sown with a grain crop there was also obtained a crop of grain in addition to the crop of hairy vetch seed. It should also be remembered that when grown with grain the crop is frequently harvested to greater advantage as the grain helps to hold the vetches from the ground.

GRASS PEAS

The grass pea is an annual legume which has been grown to a limited extent in Ontario for several years. The stems of the plants are flat, and the whole crop is greatly relished by animals when it is used as a green fodder. It produces a moderate amount of grain which is angular in form and very hard. One marked advantage of the grain of the grass pea is that it is entirely proof against the ravages of the pea weevil (Brucus pisi).

In the experimental tests over a period of ten years the yield of grain was about twelve bushels per acre.

For nineteen years seed of the grass peas has been distributed along with seed of hairy vetches and of soy beans for co-operative experiments throughout Ontario. In average yield of green fodder per acre per annum, the hairy vetch gave 8.6 tons; grass peas, 7.5 tons; and common spring vetches, 6.7 tons. It will, therefore, be seen grass peas furnish a large amount of rich fodder material and can be used either as a grain or as a fodder crop.

COW PEAS

Although much is said and written in regard to the value of cow peas for the southern states, we must remember that the conditions in Ontario are quite different. We have tested a number of varieties at the College in different years, having even as many as ten varieties under experiment at one time. It is only seldom that the early varieties will ripen any seed at the College, and these are comparatively light producers of both seed and fodder. Our ordinary field peas will give much better satisfaction in this province than will cow peas. The farmers of Ontario should give their attention to those classes of farm crops which will prove the most suitable for their conditions. It is unwise to follow advertisements recommending cow peas for this country where field peas, alfalfa, sweet clover and other legumes produce crops so satisfactorily.

EGYPTIAN PEAS

The Egyptian pea, which is frequently called Chick pea and Coffee pea, and is sold through the Ontario grocery trade, particularly to the Italians, is a leguminous plant grown extensively in the Mediterranean regions and in Central Asia. It has been used as an article of human food and also as feed for cattle for upwards of three thousand years. The seed is somewhat larger than the common pea and is enclosed in a short, thick, hairy pod, there being from one to two peas in each pod. The plant itself is seldom used except as a soil renovator, but the yield of grain is large and the peas are ground into meal, which makes a valuable cattle feed when fed in much the same way as cotton-seed meal. As a human food the peas are used in various ways. The ripened grain is sometimes prepared for the table in much the same way as we prepare Canadian beans for culinary purposes. Egyptian peas are sometimes roasted and used as a substitute for coffee.

For ten years experiments were conducted with the Egyptian pea at Guelph. The average yield in those years when it grew satisfactorily, was slightly over forty bushels per acre per annum, and the weight per measured bushel was over sixty-one pounds. The Egyptian pea, which was included in the co-operative experiments, was successfully tested on about two hundred Ontario farms, the average yield being around twenty-five bushels per acre. It was, however, a little difficult to compare it with other varieties of peas as it required a somewhat longer period for maturity. Unfortunately, owing to a blight in the crop, its growth was discontinued. It might be well to again endeavour to grow this legume in a limited way as there is frequently a good demand for the well-ripened seed.

HORSE BEANS

There are several named varieties of horse beans, a number of which have been grown at the College. For about ten years as many as a half-dozen varieties were under test. In nearly all experiments, however, the horse bean has not given satisfactory results in Ontario.

VELVET BEANS

The Velvet bean or, as it is sometimes called, the Banana Field bean is a leguminous plant, and is grown quite extensively in the southern states of the American Union. It has been tested here on several occasions, but it has never given satisfactory results. In 1925 an experiment was conducted with the velvet beans, the seed of which the writer gathered when in Florida in the winter previous. The plants, however, instead of making a luxuriant growth, grew to a height of only a few inches, producing a very small amount of fodder and no seed.

LUPINES

Both the Yellow and the Blue varieties of lupines have been tested, but the growth has always been small, and this crop cannot be recommended for either seed or fodder.

LENTIL

For several years the lentil was grown in our experimental grounds, but it has seldom produced plants of more than a foot in height. The plants seldom ripen seeds and the crop of green fodder produced was small. There seems to be but little prospects of this plant thriving satisfactorily in Ontario, although it is cultivated largely in Europe where it furnishes a good crop for forage.

VARIETIES OF CORN FOR GRAIN PRODUCTION

The production of corn for grain is at present in a precarious condition owing to the recent appearance and disastrous ravages of the European corn-borer. According to the statistics of the Ontario Department of Agriculture the number of acres used for corn for husking purposes were as follows, for each of the past four years: 1923, 285,335; 1924, 263,615; 1925, 207,767; and 1926, 179,325. It will, therefore, be seen that in this short period there was a decrease in number of acres used for corn for husking purposes in Ontario of over 100,000 acres. The decrease in bushels of corn for the same period was 8,962,805 bushels, or a falling-off of nearly one-half. The corn crop in the experimental grounds, including a large number of plots and about fifty acres of silage corn grown on the College farm annually, has been carefully examined each year for presence of the European corn-borer. Not a trace of the insect could be found until 1926, when approximately one hundred borers were found in the College corn. This insect, which had made its appearance for several years both in some sections of the United States and of Ontario, has finally reached the College, and may interfere considerably with future experiments, unless methods are found for its eradication or for its control, which will greatly reduce its ravages.

Experiments have been conducted at the College with a large number of varieties of corn, some of which do not ripen sufficiently to obtain satisfactory yields of matured seed when grown over a series of years. The following table gives the average results of each of eight varieties and strains of corn grown at the College under uniform conditions in each of the past five years, and also in each of the past twenty-one years:—

Varieties	Yield per acre (bushels by weight)	
	5 years 1922-1926	21 years 1906-1926
University No. 13	44.3	48.5
White Cap Yellow Dent (Zavitz)	44.7	44.4
Longfellow (Ontario)	38.7	42.8
Genesee Valley	44.2	41.1
Salzer's North Dakota	44.2	39.6
Compton's Early	34.5	39.0
White Cap Yellow Dent (Dawson)	38.8	37.9
Longfellow (U.S.)	37.2	34.2
Average, 8 varieties	40.8	40.9

The University No. 13 variety of corn has been obtained annually from the seed house of Northrup, King and Company, Minneapolis, Minnesota.

Twenty-one years ago seed of the White Cap Yellow Dent corn was secured from each of six farmers in south-western Ontario who had been selecting this variety for a number of years. Through unavoidable causes the sources have been reduced to two, one of these is Zavitz, in Middlesex County, and the other, Dawson, in Kent County, each of whom has been selecting this strain on his own farm for many years. Seed was secured from each of these sources each year and the results, therefore, show the immediate effect of the influence of selection by the different growers. It is interesting to know that the Zavitz strain surpassed the Dawson strain in nineteen out of the twenty-one years, the latter surpassing the former in yield per acre only in the years 1919 and 1921.

In each of the twenty-one years, seed of the Longfellow corn grown in the United States was secured through the seed trade and was compared with Ontario-grown seed of the same variety. It will be noticed that the Ontario-grown seed gave an average annual yield of shelled corn per acre of 8.6 bushels over the seed grown farther south.

The average results of the eight varieties show that the average yield per acre for the last five years is almost exactly the same as that for the whole period of twenty-one years.

A large number of varieties of corn are placed in the tests annually at the college. The experiment is always conducted in duplicate. The main object of the experiment is for fodder production. Those varieties which sufficiently ripen for seed production are husked, dried and the grain is shelled and carefully weighed. Some of those which gave the highest yield of fodder produced the smallest yield of grain. In fact, they were so immature that the results are not satisfactory, and they are not included in the summaries here presented. The following table gives the average results of each of those varieties of corn which have been grown and ripened for a period of ten years:

Varieties	Class of corn and colour of grain	Days to full tassel	Height (ins.)	Yield of grain (bushels by weight)
Northwestern Dent	Yellow Dent	79	87	50.43
White Cap Yellow Dent (Hammond)	Yellow Dent	81	92	47.01
Quebec Yellow	Yellow Flint	70	59	46.68
University No. 13	Yellow Dent	81	93	45.96
Golden Glow	Yellow Dent	83	96	43.60
King Phillip	Coloured Flint	80	89	43.19
Longfellow (Ontario grown)	Yellow Flint	80	91	42.35
Salzer's North Dakota	White Flint	81	82	41.61
White Cap Yellow Dent (Zavitz)	Yellow Dent	83	98	41.41
Mammoth White Cory	Sweet	76	67	40.87
Genesee Valley	Yellow Flint	80	89	39.27
Sanford	White Flint	83	88	37.84
Duke's Improved Essex Dent	Yellow Dent	86	101	37.42
Compton's Early	Yellow Flint	84	94	36.34
Red Blazed	Coloured Flint	80	87	35.43
White Cap Yellow Dent (Dawson)	Yellow Dent	86	100	35.19

The averages would be considerably higher except for some years in which the yields were unusually low. It should be remembered that Guelph has an elevation of about 1,100 feet above sea level, and is some distance inland from the lakes. Corn develops well for fodder purposes, but does not ripen as early in this district as on the lighter soils in the extreme south-western portion of the peninsula. The comparison of the earlier varieties, however, is both interesting and valuable.

It is interesting to notice that the variety of corn which has given the highest average yield of grain per acre per annum for the ten-year period is a dent variety and is used considerably in some sections of the prairie provinces.

The Hammond strain of the White Cap Yellow Dent is earlier and a comparatively light yielder of fodder, but gives a good ear development.

Unfortunately Quebec No. 28 was not included in the first two years of this test. It is a selection of the Quebec Yellow made at Macdonald College, and has given a uniform crop which would probably have been second on the list could it have been included in the whole test.

A co-operative experiment was started in 1916 in testing seven varieties of corn recommended for growing in Ontario by the Ontario Corn Growers' Association. In nine years, fifty-nine successfully conducted tests were made with varieties of Indian corn for grain production, with average results in bushels of grain per acre per annum as follows:

Golden Glow, 63.8; White Cap Yellow Dent, 59.5; Bailey, 58.7; Wisconsin No. 7, 58.5; Salzer's North Dakota, 55.3; Longfellow, 53.0; and Compton's Early, 51.4 It is interesting to note in these results that the four highest yielders of grain were dent corns, and the three lowest yielders were flint corns. In addition to the seven varieties mentioned the Gold Nugget variety of flint corn was used in the co-operative experiments for a number of years. In yield of grain per acre this variety ranked second in 1925, first in 1923, and sixth in 1922.

VARIETIES OF SORGHUM FOR SEED

Early Amber Sugar Sorghum grown for Grain.

About thirty-five varieties of sorghum have been tested at the college in recent years. These include different varieties of broom corn, saccharine sorghum (frequently, but improperly, called sugar cane), kaffir corn, Jerusalem corn, Milo maize, etc. There are marked differences between the classes of sorghum and also between the varieties of the different classes. The sugar canes, or more properly, sugar sorghums, contain a high percentage of sugar, while all of the other types of sorghum are non-saccharine. Two varieties of sorghum have been under test in our experimental grounds in each of twenty-three years. The average annual amount of seed per acre has varied from 542.4 pounds for the Early Amber sorghum to 58.1 pounds for the White Kaffir corn. The kaffir corn although advertised extensively, is too late for Ontario to give a satisfactory crop, either for seed or for fodder.

Six varieties of sorghum have been included in tests under uniform conditions at the college for seed production in each of the past five years. Taking forty-eight pounds as the weight of sorghum seed per measured bushel, the following gives the annual average yield in bushels of seed per acre for each of the six varieties for the five-year period: Early Amber Sugar Sorghum (Ontario-grown), 26.10; Dakota Amber Sorghum, 19.57; Early Amber Sugar Sorghum (United States seed), 6.26; Oklahoma Dwarf Broom Corn, 6.00; Feterita (United States seed), 3.80; White Kaffir corn, .20.

The Early Amber Sugar Sorghum grown and selected for many years by E. M. Zavitz, Middlesex County, has been a decidedly higher producer of seed than any other variety of sorghum which has been under test. The Early Amber Sugar Sorghum grown in the United States and secured through the seed trade gave less than one-quarter the yield of seed per acre than the Ontario strain.

In 1925 and in 1926, thirteen varieties and strains of sorghum were under test for seed production. Of these, thirteen varieties, the Early Amber Sugar Sorghum from Middlesex County was the highest producer, followed very closely by two species, No. 46 and No. 47. These two new species grow very tall, stool but little and furnish interesting material for work in plant-breeding. This report deals entirely with the sorghums as seed producers. The value of the different varieties for fodder production must be obtained from other reports.

SUNFLOWERS FOR SEED

The seed of sunflowers has been highly recommended as a poultry feed, and they are grown to a limited extent for this purpose. It is difficult to secure reliable information regarding the production of sunflower seed per acre in Canada or even in the United States, and especially in regard to the comparative value of different varieties for seed production.

A number of years ago seven varieties of sunflowers were obtained and grown under uniform conditions in our experimental grounds. In a short time some of these varieties were dropped, but those which made the highest record were continued in the experiments. The following table gives the average yield of grain per acre for the twenty-seven years in the case of each of three varieties:

Varieties	Yield of seed per acre	
	Pounds	Bushels (20 lbs. per bushel)
White Beauty	1,575	78.74
Black Giant	1,536	76.78
Mammoth Russian	1,407	70.34

In 1924 two other varieties of sunflowers were obtained, one called the Early Sunflower from the Experimental Farm, Rosthern, Saskatchewan, and the other from the C.P.R. Farm, Tilley, Alberta. The former has given comparatively poor results, but the latter is a close rival of the White Beauty variety in the experiments of the past three years.

VARIETIES OF MILLET FOR SEED PRODUCTION

Millet is rather an important crop in Ontario, especially when it is necessary to supplement the ordinary hay crop after it is found that the prospects for the latter are unsatisfactory. The millet can be sown late and give a comparatively good yield of hay in the autumn of the year. It is also sown for the production of seed and the seed yield is often quite large.

Four varieties of millet have been under experiment in each of twenty years. The following table gives the average results for the twenty-year period:

Varieties	Weight of seed per measured bushel (lbs.)	Yield of seed per Acre (bushels by weight)
Siberian	52.6	41.8
Hungarian	53.0	38.4
Golden Wonder	52.3	37.4
Common	52.9	34.3

The Siberian millet, being such a high producer, was used for selection work with the idea, if possible, of finding sufficient variations in the plants to give an improved variety.

The following table gives the average results for eight varieties of millet grown for twelve years:

Varieties	Average height (ins.)	Weight of seed per measured bushel (lbs.)	Yield per acre	
			Straw (tons)	Seed (bushels by weight)
O.A.C. No. 92	31	51.9	3.07	40.3
Golden Wonder	30	52.7	2.83	39.4
Kursk	28	52.7	2.86	38.8
Siberian	30	52.0	2.82	35.2
Hungarian	30	52.7	2.71	34.1
Common	32	52.2	2.54	34.0
Japanese Barnyard	41	31.9	4.14	22.4
Japanese Panicle	40	47.6	4.15	13.7

These results show the O.A.C. No. 92 millet to head the list in average production of seed for a dozen years. This is a foxtail millet which reaches maturity in an average of ninety-two days. In 1916 it matured in eighty days, but in 1915 and again in 1920, one hundred and two days were required from seeding time until the crop was ripe. The average length of the head is three inches, while that of the Hungarian Grass is two and one-half. The crop of a number of varieties of millet is apt to lodge and the O.A.C. No. 92 is only about average in this respect. In the twelve-year period, the Hungarian Grass had twenty-four per cent. and the O.A.C. No. 92, twenty-six per cent. of lodged crops. In the case of the O.A.C. No. 92, in some years no lodging whatever took place, while in 1920, ninety-four per cent. of the crop was lodged. In that same year, however, ninety-five per cent. of the Hungarian Grass, and ninety-six per cent. of the Common millet was lodged.

In the last five years, six new varieties of millet have been entered into our experiments, and have been grown from two to five years. These varieties are Dakota Kursk, Early Fortune, White Wonder, Italian, Common Medium and Hansen's White Siberian Proso. Of these, the Early Fortune and the Hansen's White Siberian Proso are the most promising as seed producers. Neither the Early Fortune nor the Hansen's White Siberian Proso has given as large a yield of seed per acre as the O.A.C. No. 92 variety when tested in the same years and under similar conditions.

The O.A.C. No. 92 variety of millet originated at Guelph through selection from the Siberian variety. The results show that the new variety has given fully five bushels of seed per acre per annum more than the Siberian from which it was selected. It also grows slightly taller and gives a greater total yield.

VARIETIES OF FLAX FOR SEED AND FOR FIBRE

Although the value of flax fibre in Ontario is much less than it was in war times, flax is still rather an important crop in the province. The number of acres grown of this crop in Ontario in 1926 was 7,712, and for the twenty years, 1907-1926, was 9,405. It will, therefore, be seen that the acreage devoted to flax is approaching the general average. We have had under experiment at the college, nine varieties and strains of flax in each of the past eight years, the following giving the average results for the eight-year period.

Varieties and strains	Average height (ins.)	Per cent. lodged	Days to mature	Weight per measured bushel (lbs.)	Yield per acre	
					Flax straw (tons)	Flaxseed (bushels, 56 lbs.)
Common	25	12	93	54.02	2.07	17.39
Canadian (Manitoba)	25	11	93	54.30	2.01	17.33
Dutch Child	25	11	90	54.56	2.00	16.70
Minnesota No. 25	25	10	90	54.60	1.90	16.45
Primost	25	9	91	54.58	1.97	16.32
Prairie Long Stem	26	7	88	54.56	1.86	14.56
Common (Fraleigh)	27	7	88	54.65	1.85	14.19
Longstem Ottawa 52	30	12	92	53.81	2.17	13.30
Livonian Longstem	33	13	90	54.19	2.13	11.39

As far as seed production is concerned, the common flax, whether grown in Ontario, or obtained from the west as Canadian flax, stands at the top of the list, the Ontario strain and the Manitoba strain giving practically the same results. It is very important to notice that the Long Stem Ottawa 52, although second to the bottom in seed production, is the highest of all varieties in fibre, giving 2.17 tons of fibre, being the total weight less the amount of seed produced. This was followed very closely in production of fibre by the Livonian Long Stem and this in turn was followed by the Common. It will be observed that the Livonian Long Stem and the Long Stem Ottawa 52 produced the longest fibre.

VARIETIES OF HEMP FOR SEED PRODUCTION

Hemp has been grown in our experimental plots to a limited extent, but our results in seed production from this crop are quite meagre, although we have compared it with flax and have also experimented with at least eight different varieties and selections obtained from different sources, such as Michigan, Kentucky, Illinois and Canada. In 1926 the highest yielder in seed production was Bologna, from Michigan, and the second highest-yielding strain was obtained from H. Fraleigh, Forest, Ontario. There was a decided difference in the stage of maturity of the different varieties of hemp. The two strains which were very early were started originally from Bologna Plant No. 4 and Bologna Plant No. 5, both of which we obtained from Michigan. In former experiments, flax gave more than double the yield of seed as compared with hemp, but these tests in hemp seed production have been preliminary.

ALFALFA FOR SEED PRODUCTION

A field of Ontario Variegated Alfalfa grown for seed production.

Seed production causes no apparent injury to the permanency of the alfalfa crop. The seed crop is usually cut when the pods are dark brown. When the first crop in the season is used for seed production, it is frequently cut with a self-binder and cured in shocks. Fields of the season's first cutting of the Ontario Variegated sometimes yield as high as twelve to fifteen or more bushels of seed per acre, but the average for the last few years has been about five or six. When the first crop in the season is used for hay and the second for seed, the cutting can be done with an old reaper or with a mowing machine, with or without an attachment, and the material is usually cured in bunches or in wind-rows. Yields of about seven bushels of seed per acre are sometimes secured from the second cutting, but from two to three bushels per acre is the general average.

In 1922 thirty-four plots of alfalfa were sown in our experimental grounds and the first crop has been allowed to ripen its seed each year. In each of the four years from 1923 to 1926, inclusive, each variety produced a crop of seed varying in amounts from 2.4 pounds per acre for the Ontario Common in 1926 to as high as four lots which went from 505.5 to 511.0 pounds per acre. These highest yields were produced in 1924 by two strains of Grimm, Semipalatinck and a special selection obtained from the United States Department of Agriculture, designated A.D.I.F. 21-36. Taking the average results for the four-year period the highest yield of seed was produced from the Grimm, which was seed obtained originally from A.B. Lyman, Excelsior, Minnesota. The next highest yield was produced from seed imported direct from A. B. Lyman, Excelsior, Minnesota. The Cossack, although not as large a producer of hay, came next to the Grimm in seed production. Each of these surpassed somewhat in yield of seed the Ontario Variegated. Of the last named variety obtained from different sources the Peel County seed came highest. As these plots were placed on a long range it was rather more of a preliminary than a definite test. Several of the leading varieties have since been placed under test where all of them are repeated a number of times. These should furnish additional and more conclusive information as soon as the tests are continued for a sufficient length of time. The writer prepared a report giving the results of many experiments on alfalfa conducted at the College and throughout Ontario, and this was published as College Bulletin No. 280, which contains thirty-two pages. An eight-page circular on Hardy Alfalfa was published at a later date as College Circular No. 48.

Grasses, Clovers and Sweet Clover for Seed Production

Work has been done in seed production on upwards of twenty varieties and strains of Common Red and Mammoth Red clover, also several varieties and strains of sweet clover and numerous varieties of grasses. For fuller information in regard to grasses and clovers the reader is referred to our Bulletin 269, written by Professor W. J. Squirrell and myself and covering seventy-one pages. O. McConkey, B.S.A., M.S., of this department is now carrying on some very interesting breeding work with grasses and clovers. The writer prepared a rather comprehensive report on sweet clover which was issued as College Bulletin No. 283. A more concise report giving later information is published as Bulletin No. 296.

The Production of Field Root Seed in Ontario

Within the past nineteen years, work has been conducted at the Ontario Agricultural College in the growing of mangel, turnip and carrot seed, with the object of gleaning information regarding seed production of these classes of roots in this province. We have met with very good success indeed in the production of mangel seed, but have not had quite as good satisfaction in the growing of turnip seed or of carrot seed. In two years we had almost a failure with the mangel seed, but in the other years the yield has been very good and the seed of high quality. In most years the mangel seed produced at our College had high germination and produced vigorous plants, which often formed excellent object lessons in the field, showing up better than imported seed bought through the regular seed trade.

We have done a considerable amount of selection work with the Yellow Leviathan variety of mangels. This is an intermediate mangel which gave very excellent results but had some variations. We selected for both the very best roots and the best plants for seed production. As the result of several years' work we obtained what is now known as the Yellow Leviathan (O.A.C. No. 2). This strain has given very good satisfaction in uniformity of plants, vigor of growth and yield of roots per acre, although it is sometimes surpassed in yield by one or two of the best strains of the long red mangels. This new variety has been accepted by the Canadian Seed Growers' Association as eligible for registration in Canada. The variety is used annually for seed production at the College when usually from about one-quarter to one acre is grown for this purpose. It takes two seasons from seed to seed. In the first year the mangel seeds are planted rather thickly somewhat late in the season, usually in July. The roots are harvested in the autumn and at that time weigh from about one-half to one pound each. In the following spring, these are planted in squares about twenty inches apart. We usually cut the plants with a sickle and stand them in bunches to dry, after which they can be hauled to the buildings and threshed. When hauling in, it is well to use canvas as the seed shatters readily when the plants are dry. Both seed and steckling of this variety have been distributed to farmers who wish to grow some seed on their own farms. In 1917, when the war was on and mangel seed was very difficult to obtain, we planted at the College a little less than an acre of steckling of the new variety. This area gave us 1,363 pounds of well-matured, thoroughly cleaned mangel seed, which gave a germination of over two hundred per cent. from the mangel clusters. The most of this seed was sold in the following spring at $1.50 per pound as seed stock for the production of more steckling. We could have sold our complete supply at that price but kept a few hundred pounds for fear of shortage in the following year. If we had sold the entire amount it would have brought over $2,000, for the amount of seed produced on less than one acre. Five hundred pounds of the seed was sent as foundation stock for mangel seed production in British Columbia, where the growing of mangel seed was being considerably developed. We have occasionally obtained a yield as high as a pound of seed per plant but this is exceptional. Farmers who are anxious to produce their own seed may do so by planting a few well-developed mangel roots in the spring of the year.

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